AERONAUTICAL ENGINEERING REVIEW

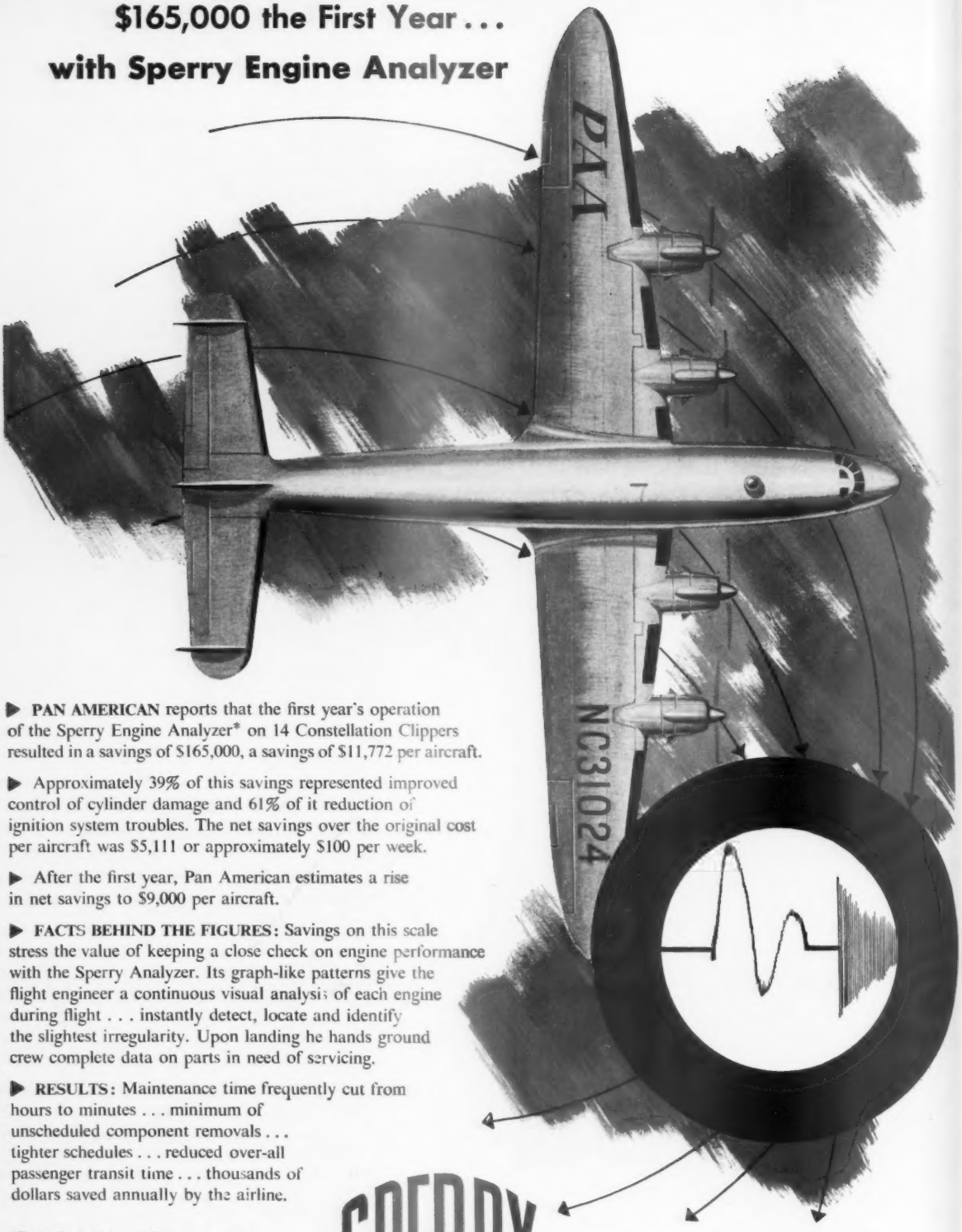
INSTITUTE OF THE AERONAUTICAL SCIENCES

SEPTEMBER 1950

SEP 16 1950

Pan American saves

$165,000 the First Year . . .
with Sperry Engine Analyzer



▶ **PAN AMERICAN** reports that the first year's operation of the Sperry Engine Analyzer* on 14 Constellation Clippers resulted in a savings of $165,000, a savings of $11,772 per aircraft.

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▶ **RESULTS:** Maintenance time frequently cut from hours to minutes . . . minimum of unscheduled component removals . . . tighter schedules . . . reduced over-all passenger transit time . . . thousands of dollars saved annually by the airline.

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AERONAUTICAL ENGINEERING REVIEW

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I. A. S. News

A Record of People and Events of Interest to Institute Members

Bane and Chanute Awards Presented to Air Force and Coast Guard Officers

Col. George W. Goddard, U.S.A.F., and Comdr. Donald B. MacDiarmid, U.S.C.G., Receive I.A.S. Honors at Dinner Held in Los Angeles on July 13, Ending Annual Summer Meeting.

The Thurman H. Bane Award for 1950

Colonel George W. Goddard, U.S.A.F., Chief, Photographic Laboratory, Engineering Division, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio, was presented with The Thurman H. Bane Award for 1950 "for his development of a new system of night aerial photography at low altitudes."

▸ **Night Photography Developed**—When Colonel Goddard was reassigned to the Photographic Laboratory in 1945, he began work on a new system for low-altitude night photography. A three-camera system was developed, giving a vertical and two oblique pictures with moving film synchronization to compensate for ground image motion. Illumination comes from an ejected photoflash cartridge, which, by bursting 600 ft. behind and 400 ft. below the photographic airplane, reduces the danger of the ship's illuminating itself as an enemy target. A photocell located below the belly of the aircraft picks up the light from the cartridge burst and signals the camera system to move fresh film into place after each picture. These three parts—the camera system, photocell, and cartridge discharger—are tied together electrically and are controlled by suitable timing devices so that they operate automatically after control information, such as altitude and aircraft speed, are set in manually.

▸ **Successful Night Test**—Years of research and development were climaxed in a night photographic flight over Manhattan on June 6, 1949, in which the British-born Colonel Goddard personally participated. A series of these cartridges, each developing 50,000,000 c.p., were ejected at intervals from a B-17 flying over the city at approximately 1,800 ft. Despite ground haze, smog, etc., the resulting pictures compared favorably with daytime photography.

The Thurman H. Bane Award, endowed by Major R. H. Fleet, honors the memory of Col. Thurman H. Bane, one of the most prominent technical officers in the U.S. Army Air Corps, who died in 1932.

Col. George W. Goddard, U.S.A.F.

The Octave Chanute Award for 1950

Commander Donald Bertram MacDiarmid, U.S.C.G., Commanding Officer, Coast Guard Air Station, San Diego, received The Octave Chanute Award for 1950 "for his outstanding contribution to Air-Sea Rescue techniques by scientific analysis and correlation of the effect of wind and waves on seaplanes during landing, maneuvering, and take-off."

▸ **Open-Sea Landings**—In order to extend the effectiveness of the air-rescue operation at sea, Commander MacDiarmid has made innumerable landings in a PBM under the severest conditions obtainable. Some of these landings were made in seas as high as 18 ft. and in winds up to 23 knots. As a result of this study, made at the Navy's request, he has been able to develop techniques that

(*Continued on page 49*)

Comdr. Donald B. MacDiarmid, U.S.C.G.

Summer Meeting Report

The Annual Summer Meeting, held in Los Angeles, July 12–14, proved to be the largest I.A.S. meeting ever held on the West Coast. More than 650 persons registered for the technical sessions, and 550 attended the Honors Dinner.

▸ **Technical Sessions**—Eighteen interesting papers were presented during the 2-day meeting at the Institute's Western Headquarters building. The five technical sessions—covering Aerodynamics; Stability, Control, and Guidance; Turbine-Powered Aircraft; Aeroelasticity and Structures; and Propulsive Systems—all played to capacity audiences. In several instances, the S.R.O. sign could have been displayed to advantage.

Top: **Honors Dinner, Embassy Room, Hotel Ambassador, July 13, 1950.** *Center:* **I.A.S. President, J. H. ("Dutch") Kindelberger, acting as toastmaster for the Dinner.** *Bottom left:* **Col. George W. Goddard makes a brief acceptance speech after receiving The Thurman H. Bane Award.** *Bottom center:* **Comdr. Donald Bertram MacDiarmid acknowledges receipt of The Octave Chanute Award.** *Bottom right:* **Major Gen. Gordon P. Saville gives the principal address of the evening.**

Many of the papers presented will be published in full in subsequent issues of the REVIEW or JOURNAL, as space permits. Meanwhile, preprints of most are still available (see page 81) and may be obtained from the New York office.

A more detailed discussion of the technical sessions will be found in the article by Messrs. Harvey and Speas on pages 16 to 25 and 43 of this issue.

▸ **Honors Dinner**—As in previous years, the Honors Dinner was held at the Ambassador Hotel, where some 550 people filled the Embassy Room to near capacity. In an atmosphere of conviviality, keynoted by the inimitable toastmastering of I.A.S. President J H. ("Dutch") Kindelberger, each honored guest at the head table was informally introduced to the audience.

Presentation of the Bane and Chanute awards, now a time-honored custom in connection with the Annual Summer Meeting, followed. The purpose of these awards and the achievements of this year's recipients are more adequately covered in the lead story of this issue on page 5.

Final highlight of the evening's program was the entertaining and enlightening address of Major Gen. Gordon P. Saville. Excerpts of his prepared speech appear as this month's guest editorial on page 14.

▸ **Muroc Field Trip**—At the invitation of Brig. Gen. Albert Boyd, 220 previously selected and security-cleared Institute members visited Edwards Air Force Base at Muroc on Friday following the technical sessions. Here, the group was given a static line inspection and an impressive fly-by demonstration of experimental aircraft presently undergoing tests.

Transportation to Muroc and return was accomplished through the use of six large air-conditioned buses, complete with State Police motorcycle escort. Fortified with a 6:00 a.m. breakfast served at the Institute's building and a luncheon and refreshments served at the Officers Club on the Base, the group found the trip both instructive and enjoyable—despite the 118-degree temperature of the day.

▸ **Success of Meeting**—The importance and value of these Annual Summer Meetings on the West Coast seem to increase from year to year. As in the past, the success of this year's meeting can be directly attributed to the enthusiasm, hard work, and cooperation of the individuals and committees who make up the Institute's Los Angeles Section and Headquarter's staff.

W. A. S.

I.A.S. Members Win Harmon Awards

Two Institute members were named as winners of the Harmon International Aviation Awards for the world's outstanding aviator and aeronaut for the decade of 1940 through 1949.

They are James H. Doolittle (H.F.), I.A.S. Past-President, Shell Union Oil Corporation, and Vice Adm. Charles E. Rosendahl, U.S.N. (Ret.), F.I.A.S., who won the aviator and aeronaut awards, respectively. Admiral Rosendahl had previously won the aeronaut award in 1927. The award for the outstanding aviatrix was won by Jacqueline Cochran, organizer of the WASP and holder of many national and international speed records. Citations awarded to the Institute members read:

▸ **James H. Doolittle:** "In recognition of his great leadership and airmanship during the period 1940–1950. By his outstanding personal leadership, skill, and courage he is symbolic of all who flew in the allied cause during World War II."

▸ **Vice Adm. Charles E. Rosendahl:** "In recognition of his distinguished leadership as regards lighter-than-air flight. It was in larger measure through his foresight, perseverance and faith that lighter-than-air craft fulfilled such a useful role in the allied cause during World War II."

Members of the advisory committee who chose the 1950 award winners included: Col. E. E. Aldrin, Fellow and Benefactor of the I.A.S., Aviation Manager, Atlas Supply Company; William R. Enyart, A.F.I.A.S., President, Simmonds Aerocessories, Inc., and President, F.A.I.; Major Lester D. Gardner, Fellow and Benefactor of the I.A.S., Aeronautical Consultant; and William P. MacCracken, Jr., Lawyer and Former Assistant Secretary of Commerce for Air.

By official definition the Harmon Awards are "American awards for outstanding international achievement." Founded by the late Clifford Burke Harmon in 1925 for the purpose of promoting international good will, the awards were made annually from 1926 to 1939. In the future the winners will be announced each year on July 4. Mr. Harmon also founded the International League of Aviators, with world headquarters in Paris. It was his suggestion that the league might become the framework for an international air police force to be used by the League of Nations as an instrument against any aggressor nation.

TRANSITIONAL ADVANCED TRAINER

Deliveries of a new advanced trainer for service at advanced training bases have been started by North American Aviation, Inc. Designated the T-28, the plane is being used to prepare Air Force pilots for jet combat fighters.

Piasecki Helicopter Corporation Joins I.A.S.

The Piasecki Helicopter Corporation recently became an I.A.S. Corporate Member. Thus it aligns itself with other member companies who are working together for the furtherance of the aeronautical sciences.

The Piasecki Helicopter Corporation had its beginning in August, 1940. A group of young engineers banded together, because of their common interest in experimental engineering, and rapidly became so engrossed in their helicopter ideas that they set out to design and, finally, to build a small helicopter, the PV-2. The PV-2 first flew in April, 1943, and was so successful that the Navy soon took great interest in the progress of the group, now known as the P-V Engineering Forum. The Piasecki Helicopter Corporation, which was chartered in 1943, received a contract from the Navy's Bureau of Aeronautics for the development and building of the XHRP-1, a tandem or double-rotor cargo and transport helicopter. The prototype, or "Dogship," was successfully flown in March, 1945, approximately 13 months after the date of the contract. The XHRP-1 was able to carry more than 1 ton pay load, or ten passengers.

▸ **More Contracts**—Early in 1946, P.H.C. received a contract from the Navy to engineer and build three XHJP-1's, an advanced and high-performance type of overlap tandem helicopter intended for exacting fleet duty. Another competition resulted in the awarding of a contract under the joint sponsorship of the Air Force and Navy to carry out the development of a large transport-type helicopter, designated the XH-16. This is scheduled to be the world's largest transport helicopter.

▸ **Production Order**—The year 1946 gave the corporation its first production order for the HRP-1 transport helicopter, tagged in the Navy as the "Rescuer" and popularly known as the "Flying Banana." Two years later, another contract for a number of modified and improved versions of the original Rescuer was received. Known as the HRP-2, the P.H.C. production helicopter is a streamlined, all-metal fuselage tandem-rotored craft of advanced design. In 1949, another production order was awarded for a substantial number of XHJP's, now known as the HUP-1. The corporation is currently producing over a score of these helicopters.

Piasecki won an important competition when it was named the winner by the Air Force in an industry-wide contest to secure an Arctic Rescue Helicopter. A large number of the YH-21 tandem-rotored "omniphibious" geared helicopters will be built for the U.S.A.F.'s Air Rescue Service.

▸ **Officers**—F. N. Piasecki is Chairman of the Board. Other officers are as follows: President, C. H. Miller; Vice-President and Secretary, W. R. Frysztacki; Vice-President, H. S. Pack; Vice-President, E. Daland; Treasurer, Controller, and Assistant Secretary, W. F. Palmer; and Chief Engineer, L. L. Douglas.

The Piasecki Helicopter Corporation maintains offices at 100 Woodland Avenue, Morton, Pa.

National Meetings Calendar

December 16	Wright Brothers Lecture, Washington, D.C.
Jan. 29–31, Feb. 1, 1951	Nineteenth Annual Meeting, New York

For details see page 43

Alexander Klemin Award Presented to Student Member

The first annual Alexander Klemin Award was presented to Fred Gene Hayos, I.A.S. Student Member, on

(*Continued on page 10*)

Necrology

Charles Lanier Lawrance

Charles Lanier Lawrance (F.), I.A.S. Past-President, died after a prolonged illness on June 23 at his home in East Islip, L.I., N.Y.

▸ **Developed Air-Cooled Engine**—Mr. Lawrance developed the first successful American air-cooled radial engine, the Wright Whirlwind, which carried Lindbergh, Amelia Earhart, and others to fame via their epochal flights across the Atlantic. His first air-cooled efforts began in 1916. At that time it was felt that the water-cooled Liberty and Hispano Suiza engines would meet all requirements during World War I and that the expense involved in the development of the air-cooled engine was not warranted. However, in 1920, the Army and Navy contracted for air-cooled engines. This was for the famous J series that later became known as the Wright Whirlwind engine. When the Lawrance Aeronautical Engineering Corporation, founded by Mr. Lawrance in 1916, was absorbed by the Wright Aeronautical Corporation in 1923, development was carried on.

▸ **Won Trophy**—In 1928, the National Aeronautic Association awarded Mr. Lawrance the Collier Trophy for his work in developing the air-cooled engine. The citation read for the "Greatest Achievement in Aviation in America, the Value of Which Has Been Demonstrated by Actual Use During the Preceding Year."

Born in Lennox, Mass., in 1882, Charles Lawrance was graduated from Yale in 1905. He was a student of architecture at École des Beaux Arts in Paris, from which he received a diploma in 1914. Later in his career he received honorary degrees from Yale, Harvard, and Tufts. He was a Chevalier of the French Legion of Honor. In 1931 and 1932, he served as President of the Aeronautical Chamber of Commerce.

He was Vice-President of the Wright Aeronautical Corporation from the time of the merger until 1925, when he was elected President. In 1928 he became Vice-President in Charge of Engineering of the newly formed Curtiss-Wright Corporation but resigned from this position in 1930 to form the Lawrance Engineering and Research Corporation, later changed to Lawrance Aeronautical Corporation. In 1944, he retired from its presidency and became the Chairman of the Board.

Charles L. Lawrance.

Mr. Lawrance was the author of many articles and reports on the development of the airplane engine, standardization of propeller hubs, transoceanic airship services, etc., which appeared in various American and foreign aviation journals.

He was also a member of the A.S.M.E., S.A.E., R.Ae.S. (Fellow), and the Aeronautical Chamber of Commerce. He is survived by his widow, the former Emily Margaret Gordon Dix.

Almon Lee Beall

Almon Lee Beall, A.F.I.A.S., Research Engineer, Wright Aeronautical Corporation, died on June 17 at his home in Packanack Lake, N.J.

Born in New York City in 1890, he was graduated from Columbia University. He was first employed by H. & N. Carburetor Company and later worked for Automotive Electrical Service Corporation, Majestic Manufacturing Company, and Vacuum Oil Company. In 1933, he joined Wright Aeronautical Corporation where he remained until his death. Throughout his career he had carried on extensive research in the field of aviation fuels and lubricants.

▸ **Inventions**—Mr. Beall was credited with the invention of design welding jigs and fixtures, as well as a single-cylinder gasoline engine. He also aided in the development of spark plugs for air-cooled motors.

In addition to his membership in the Institute, he was a member of the A.S.M.E., S.A.E., A.C.S., A.S.T.M., and American Petroleum Institute, and a Fellow of the Institute of Petroleum Technology. His wife, the former Mary C. Walrad, survives him.

Norman Ritner Beers

Norman Ritner Beers, M.I.A.S., died on June 27 at the Fort Hamilton Veterans Hospital, Brooklyn, N.Y.

▸ **Consultant—Editor**—Until last May, when he resigned for reasons of ill health, Mr. Beers had been Editor of *Nucleonics* and Consultant for the Brookhaven National Laboratory, Upton, L.I., N.Y.

Born in Missouri in 1911, he attended the University of Missouri and was graduated with a B.S. degree in Electrical Engineering and an M.S. degree in Physics and Mathematics. During the next 3 years, from 1934 to 1937, he attended Oxford University as a Rhodes Scholar and specialized in Astrophysics. His Oxford Thesis for the B.Sc. degree was entitled "Temperature Distribution in Outer Layers of Stars." In 1943, he attended the Postgraduate School, U.S. Naval Academy, where he took a course in Aerological Engineering.

▸ **War Service**—After having been associated with the college textbook department of McGraw-Hill Book Company, Inc., from 1937 to 1941, he went on active duty for 5 years with the Navy. In 1944, he was assigned as Staff Officer in the Aerological Engineering Department of the U.S.N.A., and, after his discharge from the Navy as a Lieutenant Commander, he remained on the staff as Associate Professor of Aerological Engineering.

In 1947, Mr. Beers joined the Brookhaven National Laboratory atomic project, working on the problems involved in atmospheric disposal of radioactive wastes. When he assumed editorship of *Nucleonics* in 1949, he continued at Brookhaven as consultant.

▸ **Author**—Mr. Beers coauthored the *Handbook of Meteorology*, published by McGraw-Hill, and had a number of papers published in various technical journals.

He is survived by his wife, the former Muriel Craig, and a daughter, Diana Beers.

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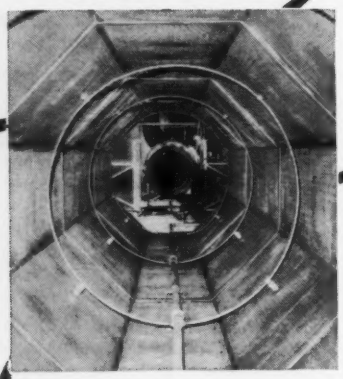

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(*Continued from page 8*)

June 12 at the commencement exercises of the New York University College of Engineering. The award is presented to a senior in the Department of Aeronautical Engineering on the basis of scholarship, leadership, personality, and student activity.

Mr. Hayos will continue his studies at the California Institute of Technology, after which he plans to enter the research and development field in jet propulsion.

Charles Froesch Appointed to R.D.B. Committee on Aeronautics

Charles Froesch, Chief Engineer, Eastern Air Lines, Inc., since 1934, has been appointed a member of the Committee on Aeronautics of the Research and Development Board, Department of Defense. Mr. Froesch will succeed William Littlewood, F.I.A.S., Vice-President—Engineering, American Airlines System, who resigned recently because of illness.

Mr. Froesch, who was born and educated in Paris, came to this country in 1912. He has been associated with various organizations in the aviation industry, including Fokker Aircraft Corporation of America, Atlantic Aircraft Corporation, and North American Aviation, Inc. He is a Fellow of the I.A.S. and a member of the S.A.E.

Mr. Froesch will serve as one of five civilian members of the committee, which also has two representatives each from the Army, Navy, and Air Force.

Aero Medical Association Elects Officers

The Aero Medical Association held its 21st annual meeting at the Palmer House in Chicago on May 29–31.

As a result of this meeting, Major Gen. Harry G. Armstrong, Surgeon General, U.S.A.F., F.I.A.S., became President-Elect; Col. Robert J. Benford, M.C., U.S.A.F., M.I.A.S., was elected to the Executive Council for a 3-year term; and Col. Arnold T. Tuttle, U.S.A.F. (Ret.), M.I.A.S., Medical Director, United Air Lines, Inc., was installed as President. Paul A. Campbell, M.D., A.F.I.A.S., Medical Research, Chicago, was reappointed Chairman of the Scientific Program Committee for the 1951 meeting, which is scheduled to be held in Denver.

General Armstrong and Colonel Benford were elected members of the first Executive Committee of the

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Association, a five-man group provided for in the newly revised constitution and by-laws. In addition, Colonel Benford was appointed as a member of the Editorial Advisory Board, *The Journal of Aviation Medicine*.

Louis H. Bauer, M.D., M.I.A.S., Editor-in-Chief, *The Journal of Aviation Medicine*, was awarded the plaque of the Founders' Association of America. He was the first president of the Aero Medical Association and is recognized as the one individual who was responsible for its organization in 1929. Dr. Bauer is also Chairman of the Board of Trustees, American Medical Association, and Secretary-General, World Medical Association.

M.I.T. Student Receives First Award of New Fellowship

Herbert Matthias Voss, an I.A.S. Student Member graduated this June from the Massachusetts Institute of Technology, received an $1,800 Fellowship for advanced aeronautical engineering leading to a degree of Master of Science.

This award was established at M.I.T. by *Aviation Week*, a McGraw-Hill publication, to spur research and knowledge in the new fields of jet planes and supersonic flight. M.I.T. has the sole power of selection of its recipient.

Royal Aero Club Elects Officers

The Royal Aero Club of the United Kingdom has announced the results of an election of officials and committee members for the ensuing year. The names of those elected to office are: President, Lord Brabazon of Tara, M.I.A.S.; Vice-Presidents, Capt. Sir Geoffrey de Havilland, H.F.I.A.S., Lord Gorell, Sir Francis K. McClean, Sir Frederick Handley Page, H.F.I.A.S., and the Duke of Sutherland. The Chairman is Whitney W. Straight, and Vice-Chairman is Sir Kenneth Davies.

Applied Mechanics Congress to Be Held in Chicago June 11–16, 1951

The First U.S. National Congress of Applied Mechanics will be held on June 11–16, 1951, in Chicago. The Illinois Institute of Technology will be host to the Congress.

National Congresses of Applied Mechanics are to be held every 4 years, between the International Congresses of Applied Mechanics, the next of which will convene in Istanbul in 1952.

▶ **Sponsorship**—Among the sponsors of the First Congress are the U.S. National Committee on Theoretical and Applied Mechanics, American Institute of Chemical Engineers, American Society of Civil Engineers, American Society of Mechanical Engineers, American Mathematical Society, American Physical Society, Institute of the Aeronautical Sciences, Society for Experimental Stress Analysis, Illinois Institute of Technology, Purdue University, Northwestern University, and University of Illinois.

▶ **Papers**—All workers in the field are cordially invited to submit papers, which should constitute original research in applied mechanics. Length must not exceed 5,000 words or the equivalent in equations, tables, and diagrams. Papers accepted and presented will be published in full in bound and printed *Proceedings*.

Complete papers or representative abstracts must be submitted to the Chairman of the Editorial Committee before April 14, 1951, and presentation is subject to the full manuscript being submitted before June 11, 1951.

Papers will be grouped by subject, and $1/2$ hour will be allotted for presentation and discussion of each paper. General lectures will also be given by outstanding authorities on subjects of general interest. Get-togethers for exchange of ideas, demonstrations, and social contact will be provided.

▶ **Inquiries**—Additional information may be obtained from the Secretary of the Congress, N. M. Newmark, University of Illinois, Urbana, Ill. The Chairman of the Editorial Committee is Eli Sternberg, Illinois Institute of Technology, Technology Center, Chicago 16. L. H. Donnell, Illinois Institute of Technology, is General Chairman, and Martin Goland, Midwest Research Institute, is Chairman of the Finance Committee.

News of Members

▶ **Wellwood E. Beall** (F.), Vice-President of Engineering and Sales, Boeing Airplane Company, completed a European tour during which he surveyed the equipment programs of nine foreign air lines.

▶ **Clarence M. Belinn** (M.), President, Los Angeles Airways, Inc., was elected a member of The Helicopter Association of Great Britain. He is also an Honorary Fellow and Vice-President of The American Helicopter Society.

▶ **William A. M. Burden,** Member, Benefactor, Historical Associate, and Past-President of the I.A.S., has been elected a Director of Reaction Motors, Inc.

▶ **Charles E. Chapel** (M.), Manager, Charles Edward Chapel & Associates, Inglewood, Calif., has received word that his recent book, *Jet Aircraft Simplified*, has been selected as one of the 100 best technical books of the year by R. R. Hawkins, Chief, Science and Technology, New York Public Library, and noted Library Journal reviewer.

▶ **Leroy R. Grumman** (F.), Chairman, Board of Directors, Grumman Aircraft Engineering Corporation, received the honorary degree of Doctor of Engineering at the commencement exercises of the Polytechnic Institute of Brooklyn.

▶ **Frank W. Hulse** (M.), President, Southern Airways, was elected a

Attention Members!

All members of the Institute are invited to submit material concerning their activities for publication in the "News of Members" columns of the *Aeronautical Engineering Review*. Responsibility for new developments, awards or honors received, and appointments to new or additional positions are some of the items that your editors believe are of interest to other I.A.S. Members. A brief letter or postal card giving exact details will be sufficient. Photographs accompanying news items will be welcomed and will be used where practicable.

Items submitted will be considered on the basis of their timeliness and general interest. Correspondence should be addressed to the News Editor, *Aeronautical Engineering Review*, 2 East 64th Street, New York 21, N.Y.

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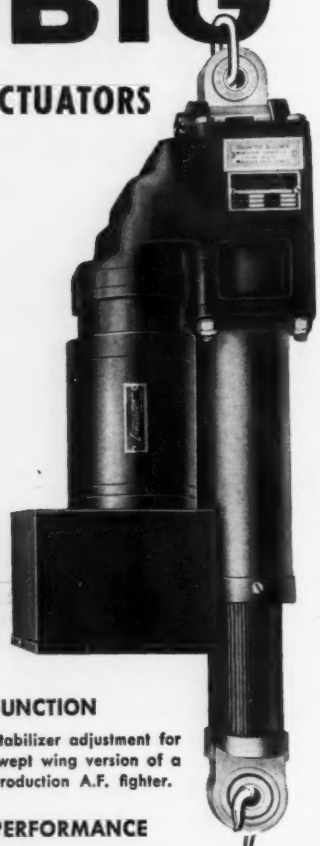
ACTUATORS



FUNCTION

Stabilizer adjustment for swept wing version of a production A.F. fighter.

PERFORMANCE

Static Load Rating: 20,000 lbs.
Maximum Operating Load: 7,200 lbs.
Operating Speed: 1 inch per sec.
Weight: 22 lbs. (Including Radio Noise Filter).

FEATURES:

(1) Overload Clutch with external adjustment.
(2) Non-jamming Positive Overtravel Stops.
(3) Position Transmitter & Radio Noise Filter built-in.
(4) 1.65 H.P., 26 Volt D.C. Motor with Magnetic Brake & Clutch.

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member of the Board of Directors of the Aeronautical Training Society. He was also appointed a member of the society's Feeder-Airline Committee.

▸ **Reinout P. Kroon** (M.), Manager of Engineering, Aviation Gas Turbine Division, Westinghouse Electric Corporation, was awarded the Spirit of St. Louis Medal of the A.S.M.E. at the semiannual meeting. The citation read "for leadership in the development of the first American design of a turbojet power plant for aviation service."

▸ **Jerome Lederer** (F.), Director, Flight Safety Foundation, was presented with a silver trophy in recognition of his contributions to furthering safety in the air. The trophy was presented by Sigmund Janas, President, Colonial Airlines, at the June 14 luncheon of the Wings Club in New York.

▸ **Paul Weeks Litchfield** (A.M.), Chairman of the Board, Goodyear Tire & Rubber Company, has celebrated his 75th birthday and his 50th year as an executive of the corporation.

▸ **J. S. McDonnell** (F.), accompanied members of the U.S.A.F. to England last July on an official inspection trip of Air Force activities there.

▸ **William A. Patterson** (M.), President, United Air Lines, Inc., has been elected to the Board of Directors of the National Travelers Aid Association.

▸ **Frederick F. Robinson** (A.M.), President, National Aviation Corporation, and Director, Bell Aircraft Corporation, was elected to the Board of Directors, Greer Hydraulics, Inc.

▸ **John F. Victory** (M.), Executive Secretary, N.A.C.A., received an honorary degree of Doctor of Laws from Norwich University.

▸ **Dr. Edward P. Warner** (H.F.), was unanimously re-elected for a 3-year term as President of the Council of the International Civil Aviation Organization.

▸ **John A. C. Warner** (M.), Secretary and General Manager, S.A.E., was awarded the honorary degree of Doctor of Engineering by Worcester Polytechnic Institute on June 18.

Members on the Move

This section has been instituted to give information on the latest affiliations of I.A.S. members. All members are urged to notify the News Editor of changes as soon as they occur.

R. W. Ayer (M.), Kenyon Instrument Company, Inc. Formerly, Assistant Director, Flight Engineering, American Airlines System.

Richard G. Bowman (M.), Assistant Chief Engineer, Republic Aviation Corporation. Formerly, Chief Design Engineer, Republic Aviation Corporation.

Alexander T. Burton (M.), Assistant to the President, North American Aviation, Inc. Formerly, Eastern Representative, North American.

Capt. Donald D. Carlson, U.S.A.F. (T.M.), Aeronautical Engineering Graduate Student, Princeton University. Formerly, Project Engineer, A.F. Proof Test Division, Department of P.T.D. Bombing Branch, Eglin Air Force Base, Fla.

Robert A. Davis (T.M.), Project Engineer, Sperry Gyroscope Company. Formerly, Instructor, Department of Aeronautics, New York University.

Robert E. DeFrees (T.M.), Aeronautical Research Center, University of Michigan, Willow Run Airport, Ypsilanti, Mich. Formerly, graduate student, University of Notre Dame.

Adolf C. Falk (M.), Partner, Janney Machine and Tool Works, Philadelphia. Continuing, Falk Engineering Service.

Capt. Charles R. Foster (M.), Student, Nuclear Engineering, North Carolina State College. Formerly, Air Inspector, Maxwell Air Force Base, Ala.

Charles R. Herrmann (M.), U.S. Naval Ordnance Test Station, China Lake, Inyokern, Calif. Formerly, Aeronautical Engineer, Stratos Corporation.

Earl R. Hinz (M.), Aerodynamicist, Consolidated Vultee Aircraft Corporation. Formerly, Associate Scientist and Instructor, Department of Aeronautical Engineering, University of Minnesota.

Rolf Hoexter (T.M.), Sales Engineer, Chas. S. Wood & Co., Inc., Industrial Insulation Contractors. Formerly, Sales Engineer, Eugene J. Brandt & Company.

(*Continued on page 82*)

APPOINTED

G. T. Willey (M.), has been appointed Assistant General Manager of The Glenn L. Martin Company in addition to his duties as Vice-President, Manufacturing. Born in England, Mr. Willey is a veteran of 32 years in aircraft engineering and manufacturing and has been connected with the Martin company since 1929.

Corporate Member News

• Plastic Tower . . . A 30-ft. high, 300-lb. plastic tower is being used by **Airborne Instruments Laboratory, Inc.,** to test the performance of the latest type, faired-in radio and radar antennas. Model airplanes up to 8 ft. in wing span and 50 lbs. in weight are revolved in simulated flight at the top of the tower. An amplifier installed in the model transmits signals from the "air-borne" antennas under test to recording mechanisms on the ground. Plastic was used in the tower construction to eliminate confusing interference in radio waves being transmitted by the model aircraft while rotating.

• Air Conditioning . . . **AiResearch Manufacturing Company** has been awarded the contract for supplying the entire air-conditioning and pressurization systems for the new Lockheed Super 1049 Constellations.

• New Gear . . . An aluminum gear with a bonded-in steel hub has been developed by **Al-Fin Division,** Fairchild Engine and Airplane Corporation. The gear has a tensile strength of about 15,000 lbs. per sq.in.

• Separate Sales Units . . . The wire rope and construction materials division of the **American Steel & Wire Company** has been split into two separate sales units.

• Won Competition . . . **Bell Aircraft Corporation** won the Navy-sponsored competition for the design of a new anti-submarine helicopter. The first order is for three experimental models, each of which will be powered with a single Pratt & Whitney R-2800 engine.

• Radar . . . C.A.A. contracts for nearly two and a half million dollars have been awarded to **Bendix Radio Corporation,** Bendix Aviation Corporation. This calls for 14 airport surveillance radar (A.S.R.) and 14 precision approach radar (P.A.R.) units. Delivery and installation at 28 civil airports in the U.S. and Alaska will begin during the summer of 1951 . . . The C.A.A. has awarded Bendix Aviation Corporation a contract calling for 44 V.H.F.-A.D.F.'s, which are to be installed at airports now equipped, or to be equipped, with surveillance radar equipment. The A.D.F. is linked with the scope of the surveillance radar and actuated by the V.H.F. radio impulses from the aircraft being contacted.

• Overload Tests . . . The B-50 and C-97A, manufactured by **Boeing Airplane Company,** have successfully demonstrated their ability to carry much more than their normal design loads. The tests were conducted as part of the routine proving of all new combat aircraft by the Flight Test Division, Air Materiel Command . . . Boeing has established a new Spares Division to handle spare parts.

• L-19A Contract . . . **Cessna Aircraft Company** has been awarded an Army Field Forces' contract for 400 L-19A's, spare parts, and equipment with a total dollar value of about $5,000,000. Deliveries are scheduled to start in December . . . Cessna has named Gleason Romans Aviation Service Company, Tulsa, as Cessna dealer for a large portion of eastern Oklahoma.

• New Furnace . . . **The Cleveland Pneumatic Tool Company** has installed heat-treating equipment that has about double the capacity of the largest single furnace previously used at this facility. The principal unit is a pit-type hardening furnace, having a working capacity of 48 in. diameter by 13 ft. deep. Other units include a stress-relieving furnace, a draw furnace (both with a working capacity to match the hardening unit), an atmosphere generator, and a special cooling pit.

• Dividend . . . **Continental Motors Corporation** declared a dividend of 10 cents per share for payment July 8.

• Attack Bomber . . . The XA2D Skyshark, manufactured by **Douglas Aircraft Company, Inc.,** has successfully completed its first test flight. A successor to the AD-Skyraider series of attack planes, the XA2D is powered by the T-40 Allison twin turboprop engine driving two Aeroproducts counterrotating propellers.

• A-3 Lifeboats . . . A series of test drops ranging from 2,500 to 700 ft. has been completed by the U.S.A.F. with the A-3 all-aluminum lifeboat built by **Edo Corporation.** The boat is approximately 30 ft. long and weighs 1½ tons with full equipment. It carries fuel for over 500 miles and is equipped with food and dry clothing for 15 occupants.

• Pack Plane . . . The XC-120 Pack Plane has been rolled out of the **Fairchild Aircraft Division** plant of Fairchild Engine and Airplane Corporation. The Pack Plane melds the trailer-truck principle with the airplane and has a detachable fuselage that can be left behind. This feature eliminates the long expensive periods on the ground while cargo is being unloaded or loaded.

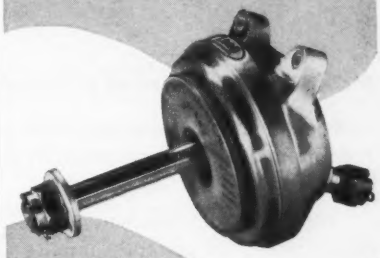
• Name Changed . . . The name of the Ranger Engines Division, Fairchild Engine and Airplane Corporation, has been changed to **Fairchild Engine Division.** The name change was agreed upon at the June meeting of the Fairchild Board of Directors.

• Dividend . . . Directors of **Fairchild Engine and Airplane Corporation** declared a dividend of 20 cents per share payable June 28 to stockholders of record June 17.

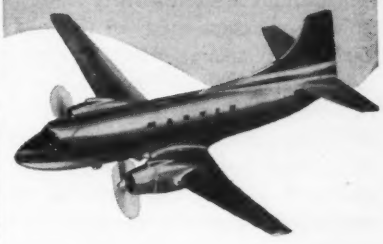
• Pallet Rollers . . . **The B. F. Goodrich Company** has developed a new 6-in. tire, tagged "pallet roller," to be used inside the new Douglas C-124 Globemaster II as driving wheels for two electrically operated elevator hoists. The rubber compound was designed to withstand temperatures ranging from −60° to 140°F. without shrinking from the traction surface and to provide good traction under all types of service conditions.

(*Continued on page 82*)

LORD
DYNAFOCALS
ADD 20 POUNDS
PAYLOAD



to
MARTIN 4-0-4



THROUGH skillful engineering and design, LORD has developed a Dynafocal Engine Suspension which saves 20 pounds of weight on each Martin 4-0-4. This weight saving adds an equal amount of revenue-producing load capacity, which means more profitable operation for T.W.A. and Eastern Airlines when their new 4-0-4's are placed in service.

Development of the MR-36J Lightweight Dynafocal is another example of how LORD's advanced engineering pays a profit to the user. LORD specializes in the control of vibration and supplying of precision-made Bonded-Rubber Parts for product improvement. Let LORD engineers assist you to obtain efficient and economical answers to your vibration problems. Write to attention of Product and Sales Engineering Department.

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Development of and for the Air Force

Remarks by

Major Gen. Gordon P. Saville,
U.S.A.F.
Deputy Chief of Staff, Development

I.A.S. Summer Annual Meeting Dinner
Los Angeles, Calif., July 13, 1950

Mr. Kindelberger, Members of the Institute, and Guests:

"Several months ago, the Chief of Staff of the Air Force appointed a new deputy 'for Air Force Development.'

"The word 'development' carries many interesting implications. It certainly implies a dynamic, rather than a static, situation. The dynamics of development in the field of aeronautics are well known to all of you.

"Within the space of fifty short years, man has been able to overcome many of the great limitations of his earthbound nature. He has greatly increased the velocity and economy of the airplane through progressive improvements in aerodynamic and structural design. He has reached extremely high speeds through the use of reaction power plants. He has overcome the obstacles of weather and darkness through clever instrumentation and the use of radiation. He stands now at the threshold of a challenging new era of supersonic flight and remote control.

"These have primarily been equipment developments. But there are many other areas in which development can take place.

"There is development of concepts and philosophies; development of organizations and management; and—most important of all—development of individuals.

"A closely knit system of private and Governmental agencies is concerned with the rapid extension of knowledge and progress in aeronautics. I should like to discuss some recent changes within the United States Air Force which will enable our particular organization to carry out most effectively its part in the overall scheme of things. These are not the usual equipment developments with which you are all familiar. Rather, they are developments of fundamental Air Force philosophy regarding the relationship of science and technology to modern aerial warfare.

"The two world wars have marked the emergence of science and technology as factors of primary importance in modern military strength. This emergence was preceded by a long incubation period, extending over the centuries during which peoples have tried to settle their differences by recourse to arms. First, man had only to out-punch or out-club his adversary in actual conflict; then the factories of a country had to outproduce those

A Guest Editorial

of the enemy, both during mobilization and in actual wartime. Today, in case of war, the 'winner' will be the nation whose scientists prove to have been more creative, especially in peacetime; whose technology satisfies, in time, the prodigious and complex needs of a modern military machine; and whose strategists outgeneral those of the enemy in the art of three-dimensional warfare. This calls for a close coupling between the economy and the armed forces of our Nation. It also calls for first-rate planning toward the integration of future developments in Armed Forces' programs, long before those new developments become available for operational use.

"In a commencement address at the University of Pennsylvania, the Secretary of the Air Force suggested these three principles to guide the Nation's military policies:

"(1) '. . . there must be peacetime *Force in Being*, so composed and trained and so ready for immediate action that it will be the deterrent to aggression we want it to be.

"(2) '. . . *the joint task concept must prevail* . . . figuring out what has to be done and then seeing how the combined Army-Navy-Air Force team can best go about doing it.

"(3) '. . . *we must plan ahead* . . . what we do this year will determine what we will have at a time in the future when the circumstances will be different than those which we are now facing. It takes a long time to build the instruments of modern war . . . this principle of future planning is of the highest importance in the building of our Military Establishment.'

"With the usual reservations associated with human nature and man-made machines and organizations, we can say that the first two of these principles are reasonably well understood. This is not equally true of the third principle, and it is in this area of long-range planning that the Air Force is continually seeking major improvements."

Development *of* the Air Force

"Some time ago, General Vandenberg asked the Air Force Scientific Advisory Board, headed by Dr. Th. von Kármán, H.F.I.A.S., to study the problems of the Air-

(Continued on page 44)

Technical Sessions—Annual Summer Meeting

Los Angeles—July 12 and 13, 1950

Hugh Harvey.

by
Hugh Harvey*
and
R. Dixon Speas†

R. Dixon Speas.

THE WESTERN HEADQUARTERS of the Institute of the Aeronautical Sciences in Los Angeles was again the scene of the Annual Summer Meeting of the Institute. During the 2 days of the meeting, July 12 and 13, 18 papers were presented in two morning and afternoon sessions and one evening session. Chairman of the program committee was **F. A. Cleveland,** Aerodynamics Engineer, Lockheed Aircraft Corporation. Attendance was the largest ever recorded at the technical meetings, registration totaling over 650.

Aerodynamics

The opening session on the morning of July 12 was on Aerodynamics, chairmanned by **R. G. Robinson,** Assistant Director, Ames Aeronautical Laboratory, N.A.C.A.

George Morikawa, Aerodynamics Engineer, Hughes Aircraft Company, in presenting the first paper, "Supersonic Wing-Body Lift," discussed in detail, with accompanying formulas, representation of lift for three groups of wing-body configurations in a stationary linearized supersonic flow. The three configurations included delta, rectangular, and clipped-delta wing-body configurations. The representation of lift of these configurations (with no afterbody) in a linearized supersonic flow is considered over the entire range of the parameters. It is pointed out that the bracketing limits of lift are obtained by simply using elementary considerations once the interpretation of these limits is recognized. By the proper choice of the independent parameters and the proper representation of the lift, reasonable approximations for the behavior of lift for intermediate values of the parameters are obtained. Although not considered in detail, further generalization is evident to other wing plan forms with straight edges and other body shapes and the representation of other aerodynamic variables such as drag, moment, and center of pressure.

The author recognizes that, in the aerodynamic design of vehicles for supersonic flight, it is essential that the bracketing limits of the important aerodynamic variables—lift, drag, moment, and center of pressure—as functions of the design parameters be known.

The main consideration in Mr. Morikawa's paper is the representation of lift for a fairly general family of wing-body configurations in a stationary linearized supersonic flow. Fig. 1 shows the family of wing-body configurations considered (see p. 18 for Fig. 1).

The paper has extensive formula derivations of the factors considered in the study of the aforementioned wing-body types. Curves are also shown in presenting results of the paper.

The interesting and informative paper by **Hans W. Liepmann** and **A. E. Bryson, Jr.,** California Institute of Technology, entitled "Experiments in Transonic Flow," presented during the first morning session, unfortunately was not available for review.

Robert T. Jones, Aeronautical Research Scientist, Ames Aeronautical Laboratory, N.A.C.A., in his paper on "The Minimum Drag of Thin Wings in Frictionless Flow," presented an analysis of the condi-

* Aviation Representative, Shell Oil Company.
† U. S. Representative, A. V. Roe Canada Ltd.

tions for minimum drag under the restrictions of motions involving small disturbances. The motion, however, may be steady or unsteady; the velocity, subsonic or sonic. Using and extending theorems derived by Hayes and von Kármán and the method of superimposing the disturbances in forward and reversed motions originally advanced by Munk, Mr. Jones analyzed the relationship of drag to thickness or volume and the distribution of lift for minimum drag.

In the case of various choices of thickness or volume for a given plan form, Mr. Jones concluded that the thickness must be so distributed that the pressure gradient of the combined field in the direction of flight is constant at all points on the wing. In other words, it is necessary to distribute the thickness in such a way that the drag per unit volume is constant over the entire wing in the combined flow field. Given the plan form and the total lift, the author calculated that minimum drag results when the lift is distributed over the wing so that the downwash in the combined flow field is constant at all points on the plan form. If the constant downwash extends continuously beyond the border of the wing, then the drag will also be a minimum with respect to changes in the wing plan form.

The influence of the boundary layer on the flow conditions in supersonic diffusers was examined by **W. M. Douglass,** Research Engineer, Navy Research Project, University of Southern California, in a paper entitled "Effects of Boundary Layer on Supersonic Diffuser Design." Previous work by E. P. Neumann and F. Lustwerk, of Massachusetts Institute of Technology, had called attention to the effect of the boundary layer on diffusion of supersonic flow and had shown that with constant area channels a series of disturbances are set up instead of the expected single normal shock.

Further work by Mr. Douglass was carried out in a tunnel having a constant area channel 4.33 by 4.74 in. and 15 hydraulic diameters in length. Hydraulic diameter is defined as (4 × cross-section area) divided by (perimeter). The Mach Number attainable in this tunnel was 2.0.

Spark shadowgraphs of the shock formation in the constant area channel of this tunnel showed that the expected normal shock is not formed but that, instead, a series of nearly normal shocks is present with accompanying regions of separated flow. Separation occurs at the first shock, and the pressure increases discontinuously at this point. Mr. Douglass demonstrated that, if this flow separation takes place in a diverging channel, reattachment must take place at a point where the area is larger, and, as a result, there is a sudden expansion loss and a drastic reduction in pressure recovery.

Observations made in the constant area channel showed that increasing the length of this channel, up to an optimum value, increased the pressure recovery. However, if the length is extended beyond this point, small changes in pressure will cause excessive movement of the shock. On the other hand, at lengths less than optimum, operating pressures will be too high. Results indicate that a ratio of length of the constant area channel to hydraulic diameter of 7.0 seems to be in order. Tests in a scale-model Mach Number 2.0 tunnel and diffuser were made to determine the operating pressure required to bring the normal shock just aft of the model. It was found that an operating pressure of 1.62 was necessary.

Stability, Control, and Guidance

The afternoon session on July 12 was chairmanned by **Clark B. Millikan,** Director, Guggenheim Aeronautical Laboratory, California Institute of Technology.

The first paper at this session, "Progress in Stall Research," by **Graham Campbell,** Research Scientist, and **Gifford Bull,** Assistant Project Engineer, Cornell

Aerodynamics Session—*Speakers include (from left to right) W. M. Douglass, R. T. Jones, Hans W. Liepmann, and G. K. Morikawa and Session Chairman R. G. Robinson.*

Stability, Control, and Guidance—*Speakers Benedict Cohn, Zegmund O. Bleviss, and E. O. Richter listen to Chairman of the Session Clark B. Millikan's contributing remarks.*

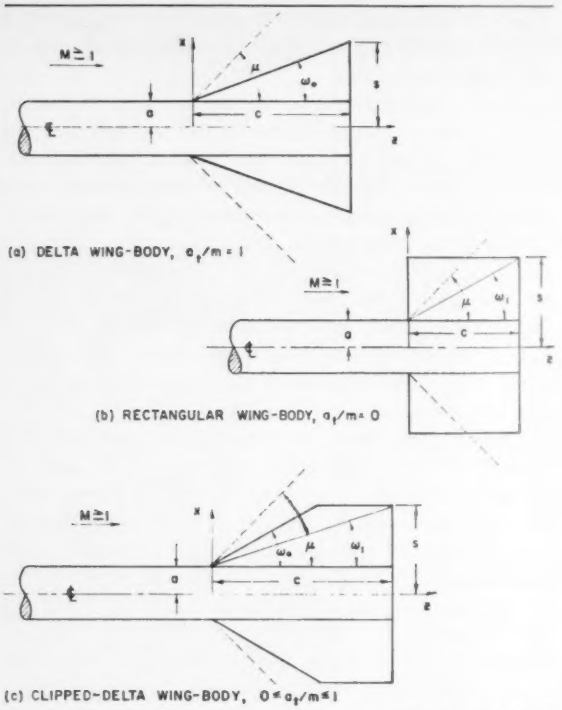


FIG. 1. Family of wing-body configurations with no afterbody.

Aeronautical Laboratory, Inc., describes in detail a stall research program that is being conducted at Cornell Aeronautical Laboratory. This research has been conducted with a Fairchild PT-26 airplane, a cantilever low-wing aircraft of conventional design. A one-fifth scale model of the PT-26 was tested at the M.I.T. Wright Brothers Tunnel.

Before reviewing the results of their research, the authors give a brief history of studies conducted on the stalling phenomena. They point out that, although it is now possible to build an airplane with excellent design characteristics, many of the design features that improve the stall correspondingly worsen other design characteristics of the airplane. The resulting compromise is pointed out, in general, to be that the stall characteristics of an airplane are made just good enough to be acceptable. With respect to the Cornell research program, the results are given in a series of 14 curves, which are discussed in detail in the text. The intent of the research is to develop an approach to the stall problem whereby stall characteristics can be more adequately forecast and dealt with. Most of the work so far done in the Cornell study has been on longitudinal motion in the stall, and, therefore, the results shown in the paper by Messrs. Campbell and Bull are predominantly on this phase of stall research. The lateral motion, however, has received some attention, and several curves, as well as a good bit of discussion, are devoted to the lateral motion problem.

Fig. 2 is indicative of the correlation that has been obtained by the authors between calculated and flight-test performance.

Other curves show confirmation between flight tests and wind-tunnel tests in many respects. The authors conclude that motion at the stall is repeatable if initial conditions are repeatable and that good flight data can be obtained in stall flight. They found it possible, but not easy, to separate the lateral and longitudinal motion at the stall, thereby greatly facilitating the analytical study of respective motions. Linear equations of motion were shown to give a reasonably good first approximation to the major longitudinal motions of the airplane except for a time delay in the measured normal acceleration.

The authors further conclude that considerable work remains to be done before it will be possible to predict with confidence the motions of a stalled airplane but that they believe the method of attack outlined in this paper to be sound. Continuous matching of the most up-to-date theoretical and empirical knowledge with primary considerations of the resulting motions of an aircraft in stall is held to be essential for a rational understanding of the stall problem.

The second paper in the afternoon session, by **E. O. Richter,** Department Manager, Transonic Research, Lockheed Aircraft Corporation, dealt with the application of drop model techniques to stability and control research. Two types of models were used in this work: the gravity-powered model used in transonic tests and the rocket-boosted coaster that can be used in any speed range. The rocket-boosted model is powered by a detachable booster or is built around a standard artillery rocket and can be either ground-launched or air-launched. However, since the lower density favors both the maximum velocity

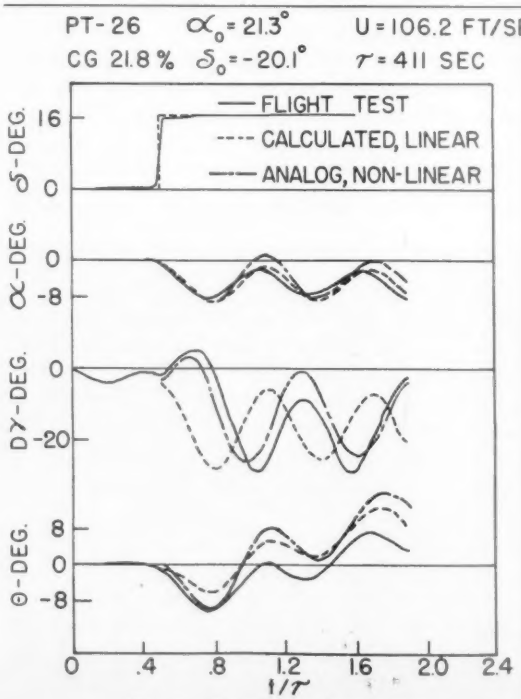


FIG. 2. Response to elevator step.

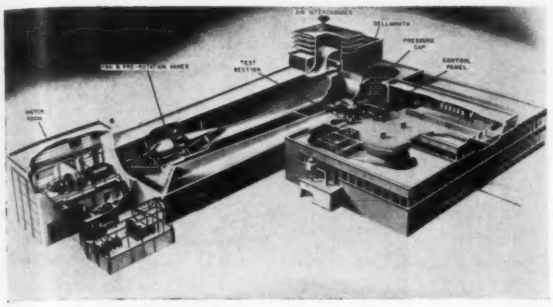


FIG. 3. Boeing Airplane Company's 8- by 12-ft. wind tunnel.

and the coasting time, the high-altitude air-launch is usually to be preferred. The model, while in motion, provides an exact solution of the equation of motion, and, in order to determine the constants of the equation, it is necessary to measure all components of the motion and the forcing function.

Mr. Richter explained in detail the instrumentation necessary for deriving the data on which is predicted the performance of the full-scale models. The equipment used in the work on which his paper is based has been under development for 4 years. In its present form it consists of a single ranging theodolite built up from a SCR-584 radar by adding precision angle rings on the pedestal, a high-intensity fine-range scope, and a bore-sight camera. A sweep-calibrator was also installed to provide a means of eliminating display tube aberration.

In operation, the radar is slaved to a manually operated optical tracker. Range, angle, and the telemeter data were photographically recorded by a system of synchronized cameras and an oscillograph. Position data were taken in polar coordinates, and the transformation to rectangular coordinates and the first differentiation, to give velocity, were made by machine computing methods.

While it was impossible for the author to give a detailed presentation of the results obtained in this work, he did give some interesting illustrations, including part of the data obtained in what is believed to be the first investigation of the flight characteristics of a complete airplane by this method.

In conclusion, the author stated that: "Comparison of the methods used in these tests with standard full-scale flight-test procedures shows very few differences except for the necessity of using a fixed program and the impossibility of making exact repeat runs. The scale of the models is large enough to avoid serious Reynolds Number effects, and, since adequate instrumentation can usually be installed in the available space, there is little reason for any marked difference in results obtained by the two methods. It is believed that the possibility of using maneuvers that would be hazardous in the case of a full-scale piloted aircraft and the possible reduction of the time span required to obtain the desired data will in many cases fully justify the employment of this technique."

Benedict Cohn, Chief Aerodynamicist, Boeing Airplane Company, presented a profusely illustrated paper covering a discussion of testing techniques and experimental results of the Boeing wind tunnel. The illustrations cover the full scope of Mr. Cohn's paper, from picturing the wind-tunnel installation to presentation of experimental results. The wind tunnel, which is the subject of Mr. Cohn's paper, is a main part of the Edmund T. Allen Memorial Laboratory, named after the noted engineer who conducted many outstanding flight-test programs for Boeing and other companies. The tunnel was placed in operation in February, 1944, and the layout is shown in Fig. 3.

The tunnel is 8 by 12 ft. closed test section, single-return type wind tunnel having a 9:1 contraction ratio and operating at atmospheric stagnation pressure over the range of Mach Numbers from the very low values used in conventional low-speed testing up to a Mach Number of 1. The test section altitude varies from nearly sea level at low speeds to approximately 16,000 ft. at a Mach Number of 1. The tunnel is powered by an 18,000-hp. Westinghouse synchronous motor with a speed regulation obtained through the use of a dynamatic coupling. One interesting step in the design of the Boeing tunnel is described in Mr. Cohn's paper—namely, a $^1/_{20}$ scale model of the tunnel. This model tunnel, powered by two 80-hp. motors, is still in use, being used now primarily for the development of special test installations that they will later introduce into the large tunnel. Several special test installations in the tunnel are described, pictured, and discussed, including the use of two-dimensional walls.

Fig. 4 is typical of the installation obtained by the use of the low-speed two-dimensional walls. The

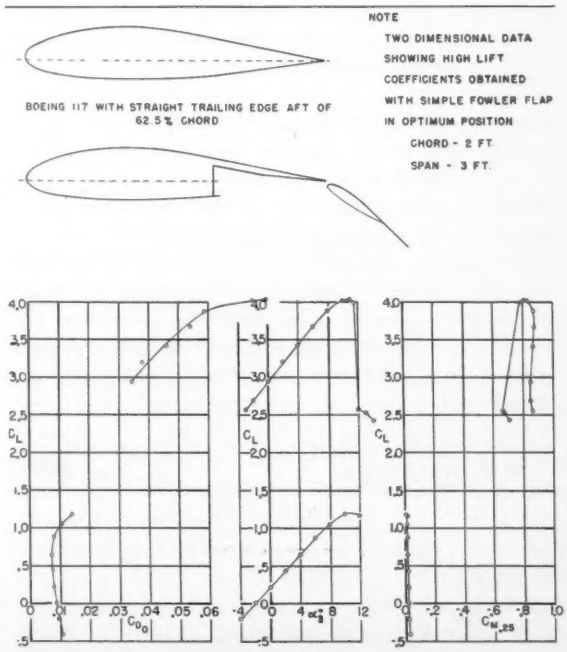

NOTE
TWO DIMENSIONAL DATA SHOWING HIGH LIFT COEFFICIENTS OBTAINED WITH SIMPLE FOWLER FLAP IN OPTIMUM POSITION
CHORD - 2 FT.
SPAN - 3 FT.
BOEING 117 WITH STRAIGHT TRAILING EDGE AFT OF 62.5% CHORD
C_L
C_{D_0}
α
$C_{M_{.25}}$

FIG. 4. Two-dimensional high lift data, three component.

low-speed and high-speed two-dimensional walls installed in the Boeing wind tunnel provided a simple and effective means of obtaining airfoil data in studying the low-speed characteristics of three-dimensional wings. It was desired, however, to accomplish rapid testing of three-dimensional wings at high Mach Numbers with essential freedom from choking in the region of the drag and lift divergence. In order to accomplish this, use of half-span reflection plane models were used and installed so that the floor served as the reflection plane. The paper gives pictures and the installation details involved in several different models being tested and also gives some technical data achieved from these tests.

The author reveals that the most important conclusion reached thus far in the Boeing tunnel (using various unconventional testing techniques, many of which are discussed in his paper) is that solutions to many complex airplane design problems of high-performance aircraft can be obtained in a direct manner using wind-tunnel test setup configurations designed to provide specific answers to specific problems.

Theoretical studies of a missile-type configuration were made by **Zegmund O. Bleviss,** Aerodynamics Consultant, Douglas Aircraft Company, Inc., in his paper "Some Roll Characteristics of Cruciform Delta Wings at Supersonic Speeds." The studies were directed to three roll problems associated with a missile-type configuration, which, as shown in Fig. 5, has a circular cross-section body, a cruciform delta wing, and some unspecified type of tail.

The three problems were: (1) roll due to aileron deflection of two opposite fins; (2) damping in roll; and (3) roll induced by pitch and yaw.

Some effects of fin-fin, wing-body, and wing-body-tail interference are also included.

Mr. Bleviss' paper develops some theoretical solutions for the roll due to aileron deflection and damping in roll. A study of these results clearly shows the effects of fin-fin and wing-body interference. Theoretical calculations for the cross-flow field in the Trefftz plane behind a cruciform wing with aileron deflection were presented for the two different assumptions of nondistorted and completely rolled up vortex sheets. In addition to the theoretical examination of a number of aspects of the investigated rolled problems, a general qualitative discussion was presented. Effects of high angles of attack were discussed, along with some nonlinear, viscous, and gap effects.

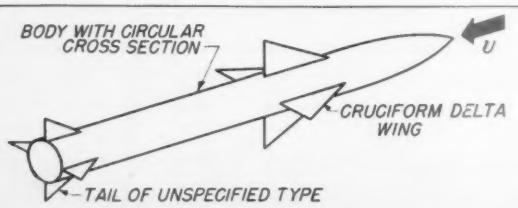


FIG. 5. Missile-type configuration.

Turbine-Powered Aircraft—*R. D. Kelly, George W. Haldeman, and Chairman C. L. ("Kelly") Johnson provoke some interesting discussion at the Wednesday evening session.*

Recommendations made for future theoretical and experimental research included the following: (1) Future slender body research should be confined to the aileron deflection and damping in roll problems. (2) Some attempt should be made to solve cruciform delta wing with subsonic leading edges. (3) Some study should be made of the nonstationary problems, with the qualification that results from nonstationary plane wing problems will be usable. (4) Work should be continued on obtaining vorticity distributions at the trailing edges of cruciform wing-body combinations. (5) The really best job of experimental research should be the systematic hunting down of nonlinear and viscous effects.

Turbine-Powered Aircraft

The evening session on turbine-powered aircraft was conducted by **C. L. Johnson,** Chief Research Engineer, Lockheed Aircraft Corporation.

George W. Haldeman, Chief, Aircraft Division, C.A.A., opened the session with his paper on "Civil Air Regulations for Turbine-Powered Aircraft," which outlined the proposals that the C.A.A. will submit for discussion with the industry.

Listing those items that will conditionally affect the regulations, Mr. Haldeman specifically mentioned sweptback, thin wings, and the turbine engine. Thin wings, of course, limit the fuel-carrying capacity and may mean that fuel will have to be carried in the fuselage. In the event this step is taken, the C.A.A. will require that special provision be taken to prevent rupture of the fuselage tanks in the event of a crash. For example, it may be necessary, Mr. Haldeman said, to fabricate these tanks to withstand accelerations of at least 20*g*. The sweptback wing also introduces problems of stability and control. Illustrating this point, he noted that sweepback results in a lower aspect ratio for the same wing area. As a result, lateral damping is reduced, and,

under certain conditions, lateral oscillations are aroused leading to adverse yaw or "dutch roll." A solution suggested by Mr. Haldeman is an automatic device that would move the rudder in proportion to yaw as measured by a rate gyro unit in the rudder circuit. Such a device would, of course, have to be dependable, and the basic characteristics of the airplane, with the device inoperative, would have to be safe and controllable.

Because there is some evidence that severe gusts may be encountered at altitudes as high as 40,000 ft., the C.A.A. is of the opinion that it is advisable to consider that the gust magnitudes are the same as are specified for sea level and that, until more information is available, no reductions or modifications be allowed for the effect of altitude. Furthermore, the author suggested the possibility of increasing the gust magnitude at design dive speed, V_D, to $22^1/_2$ ft. per sec. because of the greater proportion of the time a jet aircraft spends near its maximum cruising speed.

Various aspects of turbine-engine operation were discussed, including blowouts and relighting, turbine acceleration and its effect on take-off and landing procedures, and the use of thrust augmentation. Mechanical reliability was singled out as the most important characteristic that must be demonstrated. Initially, it will be necessary to fix overhaul periods at relatively short intervals and to increase these periods only when adequately justified by service experience.

In presenting his paper on "Operating Problems of Turbine-Powered Aircraft," **R. D. Kelly,** Superintendent of Technical Development, United Air Lines, Inc., opened with the assumption that the eventual application of turbine power plants to commercial operation is inevitable. He bases this conclusion on the smoothness and quietness of such aircraft, as well as on their speed advantage. However, Mr. Kelly cautions that, especially on short-range operation, the speed advantage of the newer aircraft is not significant, especially in view of the time-consuming ground-operating procedures. In this respect, he creates what probably will become a classic term in air transport discussions of "luggage-to-luggage" time as contrasted to block-to-block and ramp-to-ramp times. Mr. Kelly emphasizes the primary need in any good transportation system for schedule reliability over and above the need for speed. He points out that unreliability of service can soon destroy all of the advantages of speed of air travel. He observes that, within the past few years, air lines have improved their dependability and that it would be unfortunate if, in going to turbine power plants, there were not given due emphasis to continuing and further improving schedule reliability. He points out the considerations that must be given to wind variations at various altitudes and Fig. 6 shows the effect of winds on New York to Chicago operation based on an average wind condition.

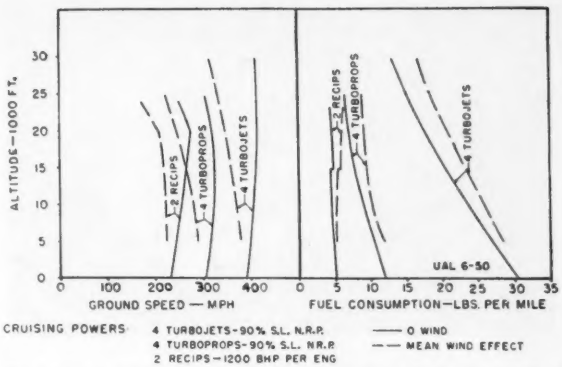


FIG. 6. Intermediate range ground speed and fuel consumption as affected by head winds.

Mr. Kelly then draws the following five generalizations from his study in reference to Fig. 6 in particular:

(1) Accurate knowledge of winds aloft is essential to the best utilization of any type of aircraft. However, with the higher flying turboprops and turbojets, it becomes doubly important in the interest of maintaining dependable schedules and reducing costs.

(2) The reciprocating-engined aircraft is less able to cope with winds in maintaining schedules, but its increased fuel consumption when attempting to make the best possible speed is less than for the turbine power plants.

(3) By reducing altitude, the turbojet is theoretically most capable of maintaining schedule speed in the face of adverse winds. But the enormous increase in fuel consumption drastically reduces range or pay load. Further, the structural limitations of the craft or the passenger discomfort may rule out low-altitude operation.

(4) The turboprop represents an attractive compromise, probably permitting the maintenance of the most dependable service without undue fuel-cost penalties.

(5) Speeds more nearly equal to that of the jet would further enhance this ability of the turboprop used in this study.

Aeroelasticity and Structures

This morning session on July 13 was chairmanned by **Benjamin Smilg,** Chief, Dynamics Branch, Aircraft Laboratory, Air Materiel Command, Wright-Patterson Air Force Base.

E. S. Hodder, Supervisor, Aerodynamics—Airplane Analysis, North American Aviation, Inc., opened the session with a study of flight-test equipment procedures and results in his paper on "Aeroelastic Problems in High-Speed Bombers."

Mr. Hodder's paper is based on some of the flight engineering development work on the North American B-45 airplane. The paper is divided into two main subjects concerned with aeroelastic phenomena: (I) Flight Test Methods of Measurement (Tail Loads,

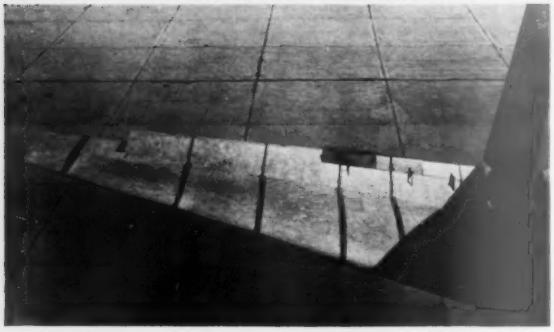


FIG. 7. B45A #023 pressure tape installation on upper surface of horizontal stabilizer.

Deflections, and Twist) and (II) Meeting Stability and Control Requirements.

The author describes in detail the test equipment and procedures utilized on the B-45, and, to the obvious question as to "why weren't the tail loads measured by strain gages on the tail attachments?" he gives two main reasons: (1) The tail structural attachments to the fuselage were sufficiently complex that it was doubtful if usable calibrations could be obtained; and (2) it was desired to know the chordwise and span loading for various flight conditions, and the pressure distributions seemed the most applicable way of obtaining them. These reasons are given because of the obvious difficulties involved in gaining pressure pickups at various stations on the tail. (See Fig. 7.) Extensive use was made of movie cameras in the flight test toward measuring distortions in flight, and the method utilized thereby was discussed in detail.

As to the second phase of Mr. Hodder's paper, three of his five conclusions sum up in good order the extensive treatment of stability and control requirements:

(1) It is a fallacy to assume that, since one airplane (designed to certain stiffness criteria) satisfactorily complies with stability and control requirements, all airplanes designed to the same stiffness criteria will also comply with these requirements.

(2) For satisfactory flying qualities, the structural stiffness of the various components of an airplane should be designed for the loads and moments imposed upon them and never to a stiffness criterion alone which omits consideration of these loads and moments.

(3) If compliance with flying qualities' specifications is to be achieved by large high-speed airplanes, the deformation of the elevator, stabilizer, and fuselage must be carefully considered during the design.

In a paper complete with extensive discussions, formulas, and resulting curves, **James B. Rea**, Research Engineer, Douglas Aircraft Company, Inc., presented "Dynamic Analysis of Aeroelastic Aircraft by the Transfer Function-Fourier Method." In opening his paper, Mr. Rea pointed out that in the aircraft industry today many separate dynamic analyses are made pertaining to the air frame. He then listed, for example, (a) dynamic stability analyses of the aircraft flight path resulting from gust disturbances or control force inputs, (b) dynamic analyses to determine the transient structural loads (especially tail loads) resulting from gust disturbances or intentional maneuvers, and (c) flutter analyses of the aircraft control system and its multielastic structure.

The author then stated that the purpose of his paper was to outline a method for accomplishing these three analyses in one single analysis. The method involved treats the airplane itself as a servomechanism and is called the Transfer Function-Fourier (TFF) Method. Mr. Rea first explains his method in general and then gives simple examples to demonstrate the concept of the Transfer Function and the use of the Fourier technique in obtaining the transient response. Also included is a brief summary of the history leading to the development of the TFF method in the field of automatic control. Examples are also given to show the conventional application of this method to the dynamic stability analysis of simple feedback servomechanisms and automatic control systems.

The paper then points out that, through extension of these fundamental concepts, an aeroelastic aircraft may be analyzed dynamically by treating it as a multiple-loop servomechanism with aerodynamic and aeroelastic feedbacks. This allows many of the methods and "tools" that were developed years ago by the electrical-servomechanism engineers in their study of the dynamic stability of communication networks, feedback amplifiers, servomechanisms, and automatic control systems to be applied directly by the TFF method to the dynamic analysis of aeroelastic aircraft. The paper also points out that many of the analysis techniques recently developed in the study of the dynamics of aeroelastic aircraft by conventional methods, especially the matrix techniques developed in the field of flutter, may be applied to the dynamic analysis of systems for automatic control.

Practical examples are then given to demonstrate the extension of the TFF method to the dynamic analysis of rigid-body and aeroelastic aircraft. These examples include: (1) a rigid-body longitudinal dynamic analysis of an airplane to determine the transient maneuvering tail loads developed by elevator displacements; (2) a longitudinal dynamic stability and performance analysis (and a limited flutter analysis) of an airplane equipped with a mechanical gust load alleviation system that is actuated by elastic wing deflection; and (3) a longitudinal dynamic analysis of an airplane to determine by a single analysis (a) the stability of the aircraft flight path, (b) the dynamic tail loads, and (c) the flutter response of the control system and the multielastic structure, where these responses result from arbitrary gust disturbances or control force inputs. (This more complete analysis includes the degrees of freedom of the air-

plane as a whole, its control system, its multielastic structure, and aerodynamic circulation.)

In conclusion, the paper points out the main advantages of the TFF method and makes recommendations for further study and development of the method.

During the summer of 1947 the Air Force made a study of the operational feasibility of aircraft through thunderstorms, particularly the frontal and prefrontal thunderstorms that are encountered in the Mid-West. **L. C. Kappil,** All-Weather Flying Division, Air Materiel Command, Wright-Patterson Air Force Base, presented the results of this work in the form of a paper entitled "Project Thunderstorm."

In this work, the Air Force used Northrop F-61 Black Widow night fighters carrying recording instruments and radar. Coordination between aircraft and ground was obtained by a ground network of 55 automatic weather-recording stations, two radar setups, the APN-19 radar (Rosebud) transponder beacon in the aircraft, and the AN/TPS-10 height-finding radar used to scan the storm area during operational missions.

As a result of this work it has been established that a thunderstorm is composed of several cells or turbulent areas varying in diameter from 1 to 5 miles, depending upon the stage of development. This turbulence appears to be least at the 6,000-ft. level and increases to a maximum between 14,000 and 20,000 ft. However, a full-grown cell has been measured as high as 67,000 ft., making it impossible for present-day aircraft to fly over the top. Within these cells, an aircraft will encounter gusts and drafts the magnitude of which varies with the development of the cell. The velocity of the drafts exceeds that of gusts by a wide margin, but the acceleration force of the former is far less. As a result, gusts are much more severe than drafts. However, the author emphasized that attempting to maintain a constant altitude in heavy drafts can easily be a pilot's first step toward serious trouble. The recommended procedure is to ignore altitude losses, even though they amount to several thousand feet (provided, of course, a safe altitude is maintained), and to concentrate principally on keeping a level attitude by the gyro horizon. In this way a minimum of stress will be imposed on the aircraft.

Lightning was found to present more of a psychological than actual hazard in a properly bonded airplane. However, as Mr. Kappil aptly put it: "Be prepared! When radio static winds up like a wild man twirling a bolo, the indication is you are approaching an area containing a large concentration of electrical charges which may be triggered off by the aircraft entering the region."

There is apparently a correlation between the speed of the airplane and the frequency of the lightning strikes encountered, for 72 per cent of the strikes recorded occurred above an aircraft speed of 180 m.p.h. It is recommended that air speed be reduced so that charges may fall off and corona discharges may be reduced in intensity. In the case of precipitation static or St. Elmo's fire and an outside air temperature of between −25° and +2° C., it is advisable to seek another altitude outside of this temperature band. Trailing antennas should be reeled in. To minimize temporary blinding, it is advisable to turn cockpit lights full-bright or wear dark glasses. Acoustic shock may be minimized by keeping the headphones away from the ears.

In conclusion, the paper states that the mechanical hazards associated with thunderstorms (such as turbulence, lightning, hail, and icing) are not in themselves extremely dangerous. The most prevalent danger is the mental hazard. Calmness on the part of the pilot is the most important factor. Reduction of mental strain through enlightenment, proper training, and experience, Mr. Kappil stated, "holds forth the greatest promise for safe thunderstorm flying in the immediate future."

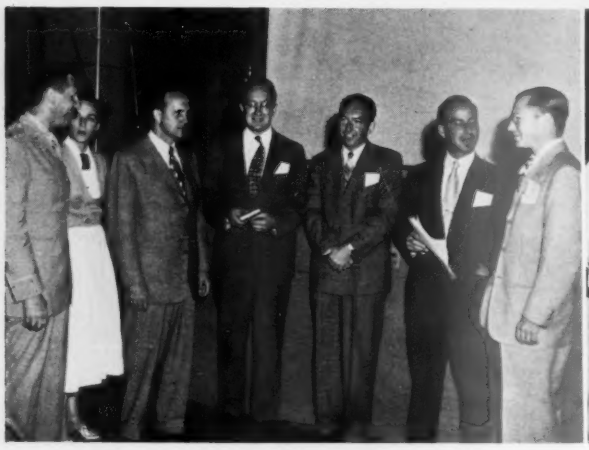
R. B. Brown and **K. F. Holtby,** Aerodynamics Unit, Boeing Airplane Company, and **H. C. Martin,** University of Washington, were the authors of a paper on "A Superposition Method for Calculating the Aeroelastic Behavior of Swept Wings." This method, the development and application of which is presented in the paper, is designed to solve the usual aerodynamic problems arising in longitudinal and lateral stability and control, as well as to provide structural design criteria. Three superposition coefficients, A, B, and C are employed, and their values are determined by combining certain cubic equations defining various angle of attack distributions—i.e., (1) the angle of attack distribution initially applied to wing, defined as α_I; (2) the elastic angle of attack distribution arising from wing deflection, defined as α_E; and (3) the angle of attack distribution at which equilibrium is established, defined as α_F.

These angles are functions of the spanwise coordinate and are measured in the direction parallel to the plane of symmetry of the airplane. Once the superposition constants, A, B, and C, have been obtained for any given type of loading, a large variety of answers related to that loading become immediately available.

Propulsive Systems

The final session of the meeting, held in the afternoon of July 13, was concerned with propulsive systems. **William Bollay,** Technical Director, Aerophysics Laboratory, North American Aviation, Inc., chairman of the session, was introduced by Roy E. Marquardt, President and General Manager, Marquardt Aircraft Company.

"Future Developments and Prospects for Propellers" was discussed by **Charles M. Kearns,** Engineering Manager, Hamilton Standard Division, United Aircraft Corporation. He opened his paper by pointing out that at the end of the war it was generally



Aeroelasticity and Structures—*Chairmaned by Benjamin Smilg, speakers for this session include Capt. L. C. Kappil (supported by the Mrs.), James B. Rea, R. B. Brown, Earle S. Hodder, and H. C. Martin.*

Propulsive Systems—*C. A. Meyer, C. B. Wainwright, F. H. Sharp, Charles M. Kearns, and Chairman William Bollay make up the speakers' panel for the concluding session on Thursday afternoon.*

felt that the era of the propeller was over. Continued research and development, however, have improved propeller efficiency to the point where the propeller will be with us as long as we have the gas turbine. For example, World War II propellers maintained 85–90 per cent efficiency at a Mach Number of 0.6, while today this efficiency is possible at Mach 0.75.

Structural developments have made possible the aerodynamic refinements of propeller blades by permitting the trend toward wider blades of reduced camber and thickness ratio with the refined airfoil shapes carried to within close proximity of the hub or spinner. Advances in design have also resulted from smoother engine operation, for the stresses resulting from engine malfunctioning can be severe as shown in Fig. 8.

Progress is also being made on the problem of stresses arising from the nonaxial flow of air through the propeller disc. This problem is largely mathematical, and conventional methods of solution are involved and tedious. The use of manual calculating machines, however, is being superseded by faster and more efficient operation on automatic punched-card computing machines.

Looking to the future, Mr. Kearns predicted that propeller efficiencies of 69 per cent or better through Mach Number 1.0 will be possible, depending on the general thickness level obtainable. The thin-bladed propeller, he stated, has a relatively constant efficiency above Mach Number 0.85 (see Fig. 9), but it is susceptible to two potential vibration problems—stall flutter and IP resonance—the resonance arising from the nonaxial airflow through the propeller disc. There is hope that stall flutter can be controlled by choice of proper airfoil sections, by use of particular types of blade plan form, and by keeping torsional stiffness and torsional natural frequency high. The problem of IP resonance will probably be more difficult to overcome, but it will take the direction of varying the blade plan form, hub size and stiffness, and blade construction.

With regard to propellers for turbines, the author stated that Hamilton Standard is attempting to provide a relatively low-cost installation that will be satisfactory for turbine operation without the ultimate in refinement by suitably modifying the standard Hydromatic propeller. For those cases where greater control flexibility is mandatory, a new propeller type has been developed. Known as the Turbo-Hydromatic, it is designed around an electronic control and for both single and dual rotation.

Following the discussion of propeller developments, a brief description of current turboprop power-plant installations was given by **F. H. Sharp,** Assistant Project Engineer, San Diego Division, Consolidated Vultee Aircraft Corporation. This firm, it will be recalled, has been responsible for the XP-81, the first turboprop installation in this country, and the XP5Y-1, which has recently been delivered to the Navy. Consolidated is also working with General Motors on modifying a Convair 240 to use two Allison T-38 turboprops.

Mr. Sharp's paper dealt for the most part with the installation of the four Allison XT-40 turboprops on the XP5Y-1, which supply 22,000 equivalent s.hp. with a power loading of 5.6 lbs. per hp. The pilot can control these engines by power control levers, one for each engine. Since each engine is composed of two sections, however, the flight engineer is provided with eight throttles so that he may control each engine section independently. The turbines are completely submerged in the wings, with the result that frontal area is a minimum; ram recovery is obtained by placing air intake ducts in the wing leading edge behind the pressure peak of the contrarotating propeller.

Speaking of the Convair Turboliner, Mr. Sharp said: "This is a 240 air liner powered by the Allison

XT-38 turboprop and is being built for General Motors Corporation. Each of the two nacelles carries a single power section coupled to its gearbox by an interconnecting structure and short drive shaft. The assembly is then mounted in the nacelle structure by a three-point suspension system. An interesting increase in performance of the airplane is anticipated as compared with the R-2800-powered 240 airplane now flying.

The paper contains a complete and informative set of pictures illustrating the power-plant installations in the XP-81, the XP5Y-1, and the Turboliner.

The third paper in the session on propulsion systems, "The Application of Pressure Refueling to Flight," by **G. E. Woods Humphrey,** President, Flight Refueling, Inc., was presented by **C. B. Wainwright,** Technical Manager of that company. For the past 16 years, Flight Refueling, Inc., in England, has been making studies of a practical means of supplying fuel to an aircraft in flight so that the aircraft can overcome what the author calls the "Kitty Hawk Compromise" of being able to carry more weight than it can lift off the ground. They have now developed techniques that are the basis for most of the refueling in flight methods now in use.

Based on the experience of Flight Refueling, Inc., the necessary characteristic of any system for transferring fuel between aircraft in flight are safety, freedom from leaks, speed, flexibility with regard to aircraft speeds and altitudes, simplicity, use of light and

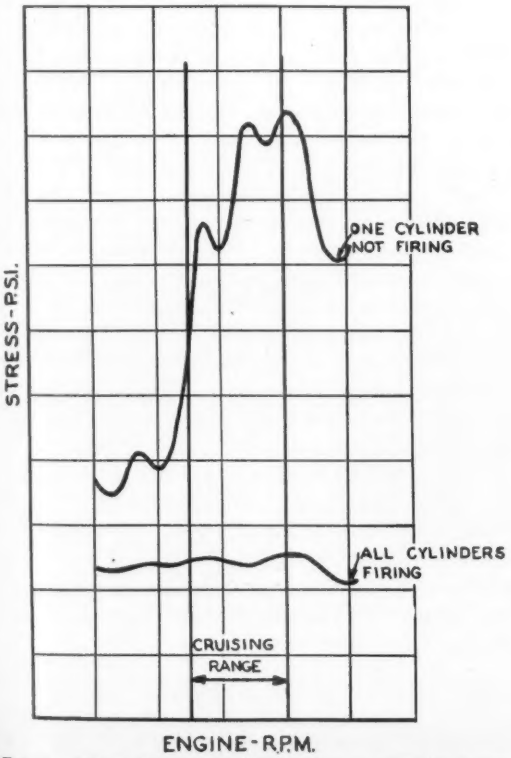


FIG. 8. Effect of engine malfunctioning on propeller stress.

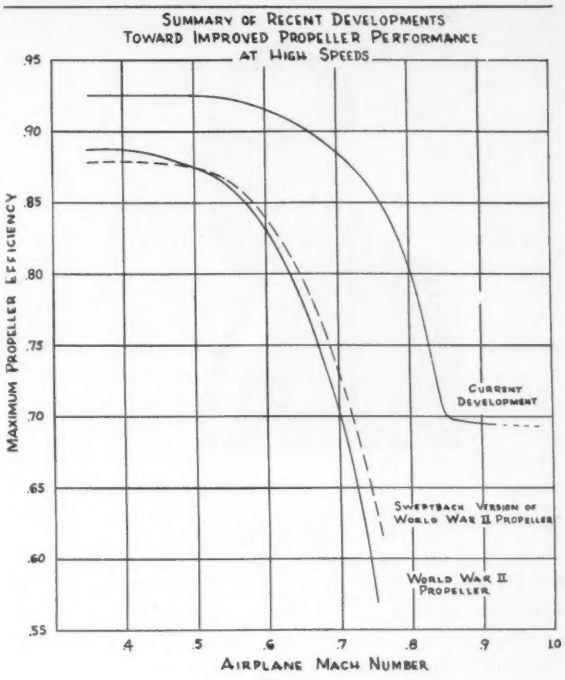


FIG. 9.

replaceable equipment, and complete reversibility so as to permit refueling of the tanker in flight.

In examining the practical applications of pressure refueling in flight, the author took as an example a 50-passenger transport flying the North Atlantic route nonstop (with normal mail and cargo load). This aircraft was assumed to have a gross weight of approximately 100,000 lbs. and to use one refueling eastbound and two westbound. With a 3,000-hour annual utilization, it was stated that with reciprocating engines it could make 114 round trips a year, 126 with turboprops and 185 with jets if the relative cruising speeds were 300, 350, and 450 m.p.h., respectively. The author estimated that to accomplish a comparable nonstop performance without refueling in flight it would be necessary to employ a transport of some 250,000 lbs. gross weight. Its pay load would amount to only 15,000 lbs. or 6 per cent. Cost of air-refueling was estimated to be one-half the landing cost of present transatlantic transport aircraft, or about $9.50 per ton of gross weight. In addition to the increased pay load, the author enumerated various other benefits, including the increased safety resulting from reducing the number of landings and take-offs.

Speaking of the military advantages of this method of fueling, the author quoted the following statement made by the late General of the Air Force, Muir S. Fairchild: "The ultimate effect of air-refueling on air operations may be fully as profound as the effect of the development of sea-refueling techniques on naval operations."

(*Continued on page 43*)

What's Wrong with Today's Helicopters?

*by F. N. Piasecki**

Piasecki Helicopter Corporation

Introduction

It is unusual for a helicopter enthusiast to select a topic of discussion such as my talk indicates. However, I feel the need for a better understanding of the problems before us. Certain criticisms have been leveled at the helicopter by some of the customers' personnel, both military and commercial. Much of this criticism emanates from sources that are not fully familiar with the discrepancies and their extent; nor are they familiar with the causes, the possibilities that are available for improvement, and what steps are being taken to make them effective.

Perhaps because of enthusiasm over the helicopter's unique characteristics and capabilities, both the customer and manufacturer have not undertaken to work out the improvements possible in the helicopter for better and more efficient performance of its varied missions. One basic problem here has been the lack of funds available to carry on such activities to the extent needed for a newly developing product.

I should like to present some of these general problems and openly discuss them so that we may know their causes, their seriousness, the possibilities that exist for their solution, and what action is being taken.

The criticisms that have been directed at today's rotary-wing aircraft may be grouped into ten categories. These will be discussed individually.

(1) Dependability

Much has been said as to the lack of reliability and dependability of the helicopter. Such nuisances as oil pump pressure loss, lubrication system blocks, bearing brinelling, clutch wear, blade tracking, etc., have been irritating in helicopter operations.

This identical problem was much in evidence in the airplane industry in the early development of aircraft engines. The solution to the question of reliability for the helicopter is along the same path taken by the engine manufacturers. The direction of this path is toward accurate knowledge of the loading conditions, the operating stresses that these loads produce, and the maintenance of high-quality material, process, and assembly requirements to provide the acceptable minimum stress levels. No effort should be spared during the design of a new helicopter in investigations of this nature on all dynamic parts. Such programs, double-checked with endurance-proof tests, will form a strong foundation for the reliability of the machine's working parts. The entire helicopter industry must re-emphasize the importance of such a foundation in every new design.

I believe that the customer would be more than willing to sponsor an increase of such test investigations and endurance programs if their importance was emphasized. Here, the Government offices charged with the certification of the helicopter's reliability can assist the industry by making the requirements difficult until more experience is accumulated. Establishing easy-to-meet requirements can do more harm than good to the industry, as well as to the individual company concerned.

The knowledge and techniques for the development and production of complex mechanical devices operating at high-frequency repeated loads are known. This fact has been successfully demonstrated in many industries. True, it is time-consuming and costly for the initial development, but reliability cannot be accomplished by short cuts, and the control of the quality in the production phases cannot be slighted. However, with such steps thoroughly accomplished, we can be sure of completely reliable operational helicopters.

As production models are tested and put into service and as the accumulated service experience is injected into improved designs, this criticism is losing its sting. This is already indicated by the fine records of such organizations as the Los Angeles Airways helicopter route, with over $2^1/_2$ years of daily operation with 96 per cent of the schedules flown.

(2) Maintenance

The maintenance requirements of today's helicopters are admittedly high. The highest percentage of

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*Chairman of the Board of Directors.

maintenance hours comes from the removal and disassembly of major components for their periodic inspections and overhaul. Routine daily flight checks, although more detailed than the airplanes', are not substantially greater. Actually, they are a minor part of the overall maintenance time.

The short inspection-overhaul periods of the components are due primarily to engineering restrictions on their operating life. Contributing causes to these restrictions are general lack of experience and operating time on certain components, isolated cases of fatigue and wear failures creating doubt as to the true service life of the component, incomplete actual stress values and their distribution, and insufficient statistical data on load size and occurrence.

The development of dynamic components of a helicopter can be considered analogous to the development of a new aircraft engine. An engine manufacturer would not dream of building one model of a new engine, testing it for a few hundred hours, and then considering it a service-tested reliable engine requiring only 500-hour overhauls. Similarly, when a sufficient number of rotor hubs and transmissions of a given model have accumulated many hours of service life without failures, then their arbitrary overhaul periods can be extended. Once dependable long-life components are developed and can be relied upon, the number of overhauls and inspections can be reduced with resultant immediate reduction of the maintenance.

Additional attention must be given to the mechanic's requirements for ease of accessibility which must eventually come from service experience. Maintenance of the rigging of the early airplanes with their wooden propellers and structures has been improved by the use of more stable materials. Such steps are not yet fully achieved in helicopter design, although considerable modern design has been accomplished. The maintenance factor is definitely under the designer's control, and, with sufficient emphasis upon it in his design, further progress can be made.

(3) Flying Qualities

The most important criticism of flying qualities is insufficient stability, requiring excessive pilot effort to maintain continuous blind flight. I feel that the helicopter, to be a completely operational aircraft, must include the hovering condition within its stability scope. Aerodynamic stability in forward flight can be approached much the same as an airplane, from which we have a great deal of experience to draw, although the body forms of helicopters are somewhat different; however, this approach is not helpful in the hovering condition where there is no effective airflow over the surfaces. There are few fundamental sources of reference for the corrective stabilizing forces in hovering. The most significant of these are gyroscopic artificial horizons and the force of gravity. The force of gravity, directly, usually proves too weak for stabilization. In addition, it is unsatisfactory in accelerated flight when it loses its identity.

There have been several stabilizing devices based on the gyroscopic principle, using rotating masses on the main rotor, with various degrees of success. Another approach is to use the fine developments of the gyro-

Fig. 1. Piasecki XHJP-1 resting on ground cradle supports and lashed down with cables for ground endurance tests. This illustrates one of the means of accumulating fatigue life data under accelerated conditions of full power.

stabilizing autopilots. It is only a matter of time before these devices will be applied to helicopter stabilization.

High and erratic control loads are an additional deterrent to blind flight, causing pilot fatigue when long flights are attempted. These loads have already been successfully reduced in modern helicopters by bungee systems and servo controls.

Therefore, although the helicopter itself is not now suitable for blind flying, methods to achieve this have already been conceived, even for the hovering condition. Some experimental flights have already been flown completely on instruments, even by pilots with limited helicopter experience. The unique demonstration of one model's flight without a pilot in the seat will be consistently repeated in the future, even while a true course in space is maintained.

(4) All-Weather Operations

The leading edges of the rotor blades have already been equipped with protective strips to prevent erosion due to rain or dust. Blades must have adquate provisions to withstand humidity and temperature effects. The original fabric-wood blades were poor in these qualities. Later plywood designs are considerably better in this respect. To ensure stable adjustments and consistent performance however, blades will have to be made of metal or other nonhygroscopic material, as is already being done, for flight in all-weather conditions. As yet unsolved is the blade icing problem, although laboratory tests show some promising solutions.

Cold-weather effects on the lubrication of the drive system have already been investigated, and suitable lubricants and provisions for arctic duty are available.

Like the airplane, the helicopter performance is reduced at elevated temperatures and/or altitudes. The initial design should have sufficient power provided for the desired operating conditions.

(5) Vibration

Much humor is expended on the helicopter because of its vertical bounce, as well as its vertical lift. Most of this humor stems from real causes, although it is frequently exaggerated. All the causes of vibration emanating from the rotor system are not fully known as yet, but means to investigate them as to their seriousness and their effect upon the structure, as well as methods by which their discomforting feeling can be eliminated, are definitely known and available to the designer. These considerations must be given to the design in its original conception because the basic structure must be designed with its natural frequency relative to the rotor frequency kept in a proper ratio. It is true that unfortunate occurrences have happened in early designs. For example, in one case the natural frequency of a fuselage coincided with the 3-per-rev of its rotor, so the resulting apparent vibration caused a great deal of concern to the pilot and the occupants.

The solution to many of the vibration problems is careful design. Blade unbalance, both spanwise and chordwise, has been controlled within acceptable limits in propellers, especially after the advent of all-metal propellers. We can expect to follow a similar path in rotor-blade design. Resonance of the blade with exciting frequencies within the normal flight range must be avoided. The helicopter engine is a pronounced source of vibration, since it is normally housed within the fuselage. Greater care is needed to isolate its vibrations from the aircraft structure. The use of gas turbines instead of piston engines will remove the source of most engine vibration. Shafting and gears are a source of very high frequency vibration, which is troublesome mostly in the form of noise. There is considerable airplane experience with noise and how to insulate the cabin from it. Thus it can be seen that most helicopter vibration is not so mysterious but is within our ability to overcome provided we give it the attention it needs.

(6) Pay Load

The relatively limited pay load of today's helicopter is improving with each new design. Much remains to be done on this factor, since the useful load of the largest helicopter is less than one-tenth of that of the largest airplane.

Pay-load capacity can be increased both by increasing the size of the aircraft and by bettering the lifting efficiency in a given size.

Helicopters the size of a DC-4 are under construction. There does not appear to be any question as to their feasibility. One project plans a rotor diameter sufficient to lift a light tank.

In addition to size growth, our increasing knowledge permits us to increase the lift capacity of present sizes. We can increase the number of pounds carried per square foot of disc area in the same way that the airplane wing loadings have increased from their early low values. Research programs concerning autorotation, with higher disc loadings and faster tip speeds, will provide the detail information to enable the engineer to design the rotor to carry more load for its size.

Useful load of present machines can also be increased by greater structural and aerodynamic efficiency. Modern helicopters can carry a useful load of approximately one-third of the gross weight. The mere substitution of a gas turbine for the present piston engine can increase the useful load by 35 per cent. The increase in pay load, of course, as contrasted with useful load, depends upon the range, but, even at a range of 200 miles, the improvement due to the turbine amounts to nearly 20 per cent.

(7) Range

The limited range of the helicopter in relation to the airplane is a point of discussion. This criticism is not so severe as it first may appear, since most of the heli-

copter's primary functions are only in short hauls. However, this is a problem to be considered for longer range missions. Little attention has been given to drag in helicopter design because of weight considerations and the preference for pay load rather than high speed. However, drag appreciably affects the range of a helicopter, and drag-reducing measures, such as retractable landing gear and auxiliary lifting devices, can be added to improve materially the range. These are the same improvements that the conventional fixed-wing craft went through in order to add range. One helicopter design today, even though not incorporating these improvements, is capable of being ferried over the longest overwater hop for a round-the-world flight without refueling.

The ability of the helicopter to hover over a spot without landing offers an alternate means of extending range by flight refueling from vessels at sea or parachuted containers. U.S. Coast Guard off-shore rescues from vessels have already demonstrated this technique.

(8) Speed

In these days of jet and rocket speeds, the 140 m.p.h. maximum speeds of today's helicopters may seem snail-like. We have made excuses to ourselves in the past by pointing out that the function of our aircraft is not to travel great distances and that therefore high speeds were not a necessary part of our performance requirements. Many military and commercial purposes appear now, such as arctic rescue and off-shore rescue, assault transport, etc., that not only desire, but in reality need, higher speeds to perform more effectively their mission.

The limitation on the top speed of today's helicopters is basically due to the stalling of the retreating blade. The limit can be raised by increasing the rotational velocity of the blade to delay the tip stall phenomenon. This, however, must be paid for by a decrease in the efficiency of the rotor in its power-thrust ratio. Another means of materially increasing the forward speed of a helicopter is by unloading the rotor so that the angle of attack of the retreating blade can be reduced, thus delaying the tip stall and the excessive drag it produces. The reduction of drag in the external shape and cleanliness of helicopters has still not come up to the 1935 airplane. There is room for considerable improvement with the use of retractable landing gears and more streamlined external appendages.

In order to provide the thrust required to overcome the higher drags of the higher speeds, additional thrust producing means must be provided. These means could be in the form of a propeller or jet thrust. With a combination of the above modifications to present-day helicopters, today's 140 m.p.h. speeds could undoubtedly be brought above the 200 m.p.h. mark and, with a little additional development, eventually reach speeds above 250 m.p.h.

(9) Complexity of Construction

Although the helicopter has eliminated the airplane's wing and its attendant flaps and ailerons, as well as the empennage, it has substituted shafting, gear boxes, internal self-cooling power-plant units and a rotating lift system connected by a mechanical hub with a precise mechanical control system. Because there is no forward speed in the hovering condition, lift must be generated by rotation of the wings. This further requires a portion of the control system also to rotate. These rotating parts cause most of the apparently complex construction. Simplification of these functions does not appear to be easily attainable without paying a considerable penalty, such as in a jet rotor solution that eliminates many of the transmission and power-plant parts but adds a large increase in fuel consumption as a deterrent factor.

Much can be done, however, in simplifying detail design. Because of the experimental nature of most development models in the past, detailed design features have not utilized production-type methods of manufacture, such as forgings, in order to reduce the initial cost. With increased attention to production details, many parts can be simplified in their construction, and several parts can be combined into one, thus reducing the complexity of the detail design.

(10) Cost

Today's helicopter costs an average of $30 to $40 per lb. of useful load. This is in comparison to the transport-type airplane's average cost of $15 to $25 per lb. of useful load.

As previously mentioned in discussing the complexity of construction, the helicopter has certain advantages in that it does not contain some of the large structural areas of the airplane. It is penalized, however, with many mechanical components. These mechanical units are expensive to manufacture when in small-lot production but, as demonstrated by the automobile industry, can be materially reduced in cost when high-volume production tooling can be applied to their manufacture. The application of existing machine tools for the production of mechanical components is a more feasible economical development than the special high-volume tooling for such large components as airplane wings and tails.

Standardization of materials, processes, components, and accessories is another method of achieving large cost reductions.

The helicopter has not yet enjoyed volume production even when compared to the airplane. The maximum peacetime helicopter production plans have been in units of 100 and are usually far less. By combining military requirements and timing production orders, the number of units per manufacturing run could be well increased. With the advent of large-volume orders, the unit cost of the helicopter will be reduced by

(*Continued on page 42*)

Some Speculations on the Next Decade in Airplane Development

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Introduction

GREAT ADVANCES IN AERONAUTICS certainly are to be expected in the next 10 years. These will probably include further growth in traffic on the air lines of the world, adaptation of new electronic devices, improvements in the performance of jet propulsion systems, our first use of supersonic guided missiles, the development of tactical supersonic airplanes, and the introduction of atomic propulsion. The discussion to follow, however, will relate for the most part to supersonic airplanes and to predictions concerning their characteristics.

The Difficulty of Making Predictions

Predictions in aeronautics are not easy to make, even for periods as short as 10 years. This is seen in looking back over the 5 decades that encompass the important events in the history of powered flight. The era from 1900 to 1910, for example, was the time of birth and infancy of mechanical flight. The decade began against a background of thousands of successful glider flights and several unsuccessful attempts at powered flight.

Finally, with the development of a sufficiently light engine and its incorporation in an air frame having suitable stability and control, the Wright brothers made the first powered flights. While optimistic predictions for future developments were made by some, there were also those who were both pessimistic about the future and highly skeptical of events that had actually occurred. A German newspaper noted accounts of the Wright brothers' flights with the headline, "Amerikanisher Bluff," while the *Scientific American*[1] printed an article on the "alleged" flights entitled, "The Wright Brothers' Airplane and Its Fabled Performances."

The *London Daily Mail*, apparently made air-minded by the development of lighter-than-air craft, headed the Wright brothers' story,[2] "Balloonless Airship!"

Subsequently, in 1908, the U.S. Army Signal Corps took delivery of the first military airplane from the Wright brothers. Successful airplanes were also built by other fliers, both here and in other countries. The airplanes of this decade were so lightly loaded that gusty winds were a serious hazard and were so slow that cross-country flights were almost impossible against nearly any wind.† This caused an English predictor, J. T. C. Moore-Brabazon, to say:[3] "I do not think a large, passenger-carrying aeroplane, faster than trains or steamers, is already in view in this country owing to the high speed of the average winds, which is 20 miles an hour." Finally, in 1910, missiles were dropped in flight from an airplane equipped with a bombsight, radio messages were sent to the ground, and a rifle was fired in flight. Thus, the first decade of flight saw the beginnings of future greatness, but there was confusion as to the usefulness of the new vehicle.

The Decade Is a Significant Time Interval

The present decade, that beginning in 1940, has seen the subsonic airplane become well established militarily and commercially. It was commonly believed[4] in 1940 that the sonic "barrier" would be a limit to airplane speed, "not one imposed by the laws of any State but by the laws of Nature." In addition, the upper economical speed of air liners was widely believed[4] to lie in the 200–300-m.p.h. range. It was said[4] that these limits were being approached with "some degree of finality."‡ History, of course, said otherwise, and the present decade did not recognize these limits to the development of aviation. On the contrary, the progress made in these 10 years has been truly remarkable. Many men flew faster than sound, although this was done under specialized circumstances in aircraft of limited practical supersonic utility. Transports in the 300-m.p.h. class appeared in large numbers, and those in the 500–600-m.p.h. category were generally envisioned. Bomber fleets of over 1,000 airplanes were used. Radar and other electronic devices were invented to provide vision and guidance for airplanes in otherwise difficult situations and in dangerous flying weather. The most powerful bomb known to man was devised and thereby made the airplane a weapon of colossal offensive power. Transport of men and goods by air grew to large propor-

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† The aviation literature of this early decade contains frequent mention of the important effects of the wind on flight. In fact, the wind speed imposed a barrier on the utility of the airplane until the ratio of cruising speed to wind speed became significantly greater than 1.

‡ The invulnerability of the sonic barrier was questioned somewhat later in the decade by a few scientists. In 1944, Dr. Th. von Kármán said,[12] in answer to the question of whether we would ever fly faster than sound: "I do not believe that at the present time this question can be answered by a straight 'yes' or 'no.'" Shortly thereafter, von Kármán and Major Ezra Kotcher, of the U.S. Army Air Forces, spearheaded the procurement of the X-1, first airplane to penetrate the supersonic region.

tions during the war and in the historic Berlin air lift. In this decade, then, we have seen the airplane not only reach a stage of great usefulness but, in addition, show promise of further rapid growth.

Great strides have thus been made in aviation in spaces of but 10 years. With the very security of this country dependent on air power, it is essential that we not only discuss the important aeronautical developments likely to occur in the next decade but also do all in our power to maintain world leadership in these developments. There is, unfortunately, considerable evidence to show that we have not always been the leader in aeronautical development. For example, Fig. 1, from an analysis[6] of aircraft power-plant trends by M. U. Clauser, shows a serious decline in improvement rate in speeds of the world's military airplanes following World War I. This country's rate declined relatively more than those of other countries. After a brief period in the early twenties, our leadership in speed and altitude performance passed to Britain and Italy, and even amateur racing plane designers produced record-breaking aircraft superior to our military craft. At the present time, U.S. Air Force developments in jet fighters and in research aircraft have again brought speed leadership back to this country. A future loss of leadership must be avoided, and, in particular, it is felt that top-grade supersonic vehicles *must* come from our laboratories and factories in the next decade. Remember the 1925 testimony[5] of a Deputy Chief of Staff of our Army, who said: "I see no reason why the range of a military airplane should ever exceed 3 days' march by the infantry."

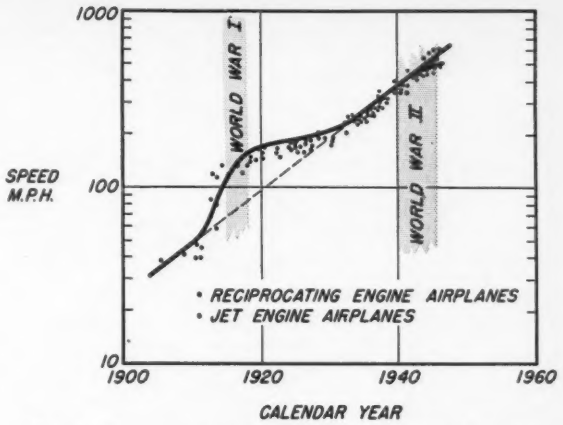


FIG. 1. Progress of maximum speed of military airplanes.

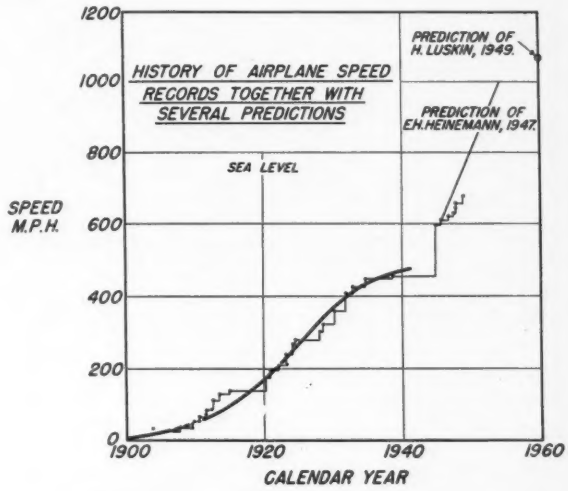


FIG. 2.

THE TRANSITION TO SUPERSONIC SPEEDS

There seems to be little doubt at this time that we stand at the threshold of the first supersonic decade. One no longer asks "if?" but rather "when?", "how fast?", "how?", and perhaps "why?" The history of airplane sea-level speed records,[7] which furnishes a statistical basis for studying growth, together with several recent supersonic predictions, is shown in Fig. 2. It is seen here that a fairly complete growth curve is formed by the data for propeller airplanes and that a new trend has been started by jet aircraft. The emergence of such a new trend is generally caused by a revolution, or mutation, in the growing thing.[8] We can, therefore, ask about the nature of the mutation in aeronautics. The revolution in airplane design stems, first, from the excellent characteristics of jet engines at high speeds and, second, from the creation of air-frame configurations properly shaped to accommodate the compressible nature of high-speed air streams. A graphic demonstration of the nature of these changes and their consequences is shown in Fig. 3. In this figure are plotted drag and maximum thrust curves for several airplanes that typify the changes being considered. The ability to climb or accelerate is shown by the excess of maximum thrust over the drag, and the high speed is at the right-hand intersection of the two curves. Airplane 1, equipped first with a propeller-piston engine combination, is seen to have a moderate high speed. The same airplane equipped with a turbojet gains considerably in speed. It is important to notice the decreasing thrust of the propeller as speed increases and, in addition, to notice the nearly constant thrust of the turbojet. The jet engine, therefore, has a valuable characteristic for high-speed applications. One should also observe the sharp increase in drag near the high speed of the turbojet-powered airplane. This is the compressibility effect which, for conventional rounded shapes, leads to prohibitive drag penalties at higher speeds. The subsonic intersection of drag and thrust curves is universal for conventional airplanes and, during the past 46 years, has only been slowly moved toward higher velocities.

The revolutionary nature of supersonic airplanes can now be explained. As shown in Fig. 3, airplane 2, powered by turbojets with afterburning, has thrust that rises significantly with increases in speed. In addition, a change in air-frame shape to one with extremely thin sharp profiles so reduces the compressibility effect as to completely eliminate the subsonic intersection of the

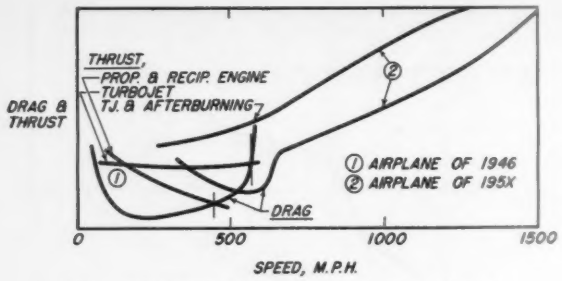


FIG. 3. Drag and thrust curves for several aircraft.

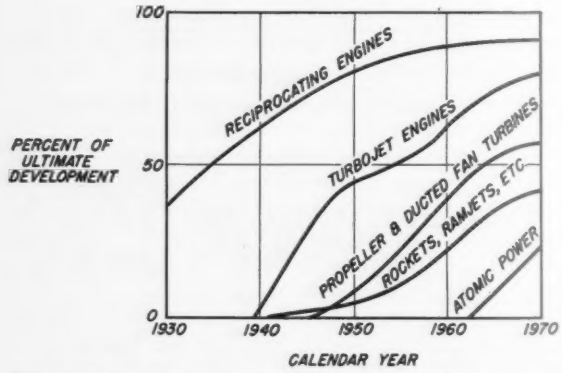


FIG. 4. Estimated timing of development of various types of aircraft power plants.

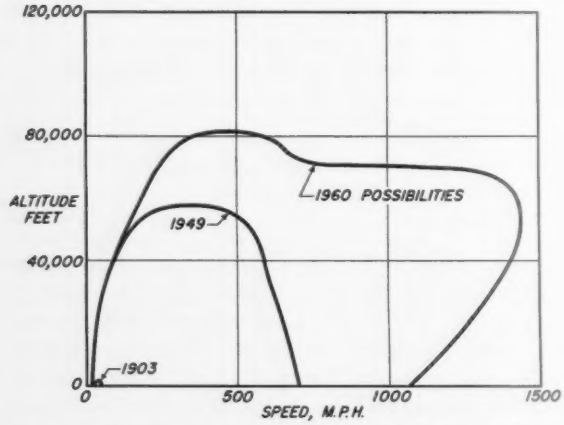


FIG. 5. Airplane performance history, together with a prediction.

drag and thrust curves. The intersection occurs, instead, well into the supersonic range, and a great new speed region thus opens up.

PREDICTIONS FOR THE NEXT DECADE

The exploitation of the supersonic régime will begin in the next decade. Fig. 4, from the Clauser paper,[6] shows an estimate of the rate of power-plant development in the future. Fig. 5, which is based on Clauser's study, gives a prediction[7] for speeds and ceilings thought to be possible by 1960 in airplanes having air-breathing engines. The engineering problems associated with achieving superior performances are, just as in 1900, the design of sufficiently light and small power plants per pound of thrust and the development of air frames having suitable stability and control. It is no longer necessary, however, to be so concerned with the adverse effect of head winds! If the trends observed in the past continue in the future, fighter airplanes will show approximately the following changes between 1950 and 1960: a doubling of speeds, gross weights, and wing loadings; a tripling of horsepowers. A new barrier, that due to frictional heating of the vehicle skin by the adjacent air layers, will be the important obstacle to progress in the supersonic age. The heating increases with velocity to the extent that the maximum speed of supersonic airplanes may have to occur at part throttle. Further details of the main characteristics of supersonic airplanes are to be found in reference 7.

The discussion so far has been primarily concerned with the piloted airplane. The advent of the supersonic airplane will soon bring the speed of manned craft into the ballistics category. This fact raises a question about the nature of the distinction between an aircraft and a missile. The choice of configuration, type of power plant, and equipment carried by one of the devices will depend upon the mission for which it is designed. Some vehicles will be called missiles and some airplanes, but the distinction will not always be obvious or important. For example, the supersonic airplane envisioned as the probable future fighter, when properly armed, might well be considered to be the first stage of a two-stage missile.

WHY FLY FASTER THAN SOUND

The discussion so far has attempted to answer only the "when?", "how fast?", and "how?" of supersonic airplanes but has not touched the important question "why?" Why do we wish to fly at supersonic speeds? The answer goes back to the fact that war is, by nature, a contest between armed forces.[9] Army is pitted against army, fleet against fleet, and man against man. The contest takes in many other things, all paired off—production capacities, scientific developments, economic strengths, natural resources, etc. This contest between the opposing forces is a combination of many distinct engagements.[10] With regard to the subject being considered, an important future engagement may be that between fighter and bomber airplanes. The bombers presumably carry enormously expensive and powerfully destructive bombs. The great monetary and weapon value of the bombs means they are scarce, cannot be wasted by failures of the bombers to get to the target, and hence must be delivered with as high a probability of success as possible. These considerations lead likewise to a philosophy of defense in which a high probability of bomber kills is vitally important. The bombers would like to have a clear-cut and absolute advantage. To have one, they might fly higher than the fighters, or they might outrace the fighters. Either of these alternatives requires a distinctly superior level of technological achievement, one of which no

country dare feel sure.* If it is assumed, on the other hand, that an absolute speed or ceiling advantage is not possible, then the engagement between fighters and bombers can involve a period of chase and a period of combat. A simple example of such an engagement is shown in Fig. 6. It is assumed that the action begins at the time when the bombers, having a speed V_B, are S miles distant from the bomb release point. The bombers are vulnerable when flying across the space S.† At the same time, the fighters with speed V_F are l miles from the bombers. Now we can ask: "What is the importance of speed to the bomber?" An answer can be obtained by assuming that the bomber losses will be in some degree dependent on the combat time, t_c, the period between the time of interception and the bomb-drop time.[9] This interval is given by the formula

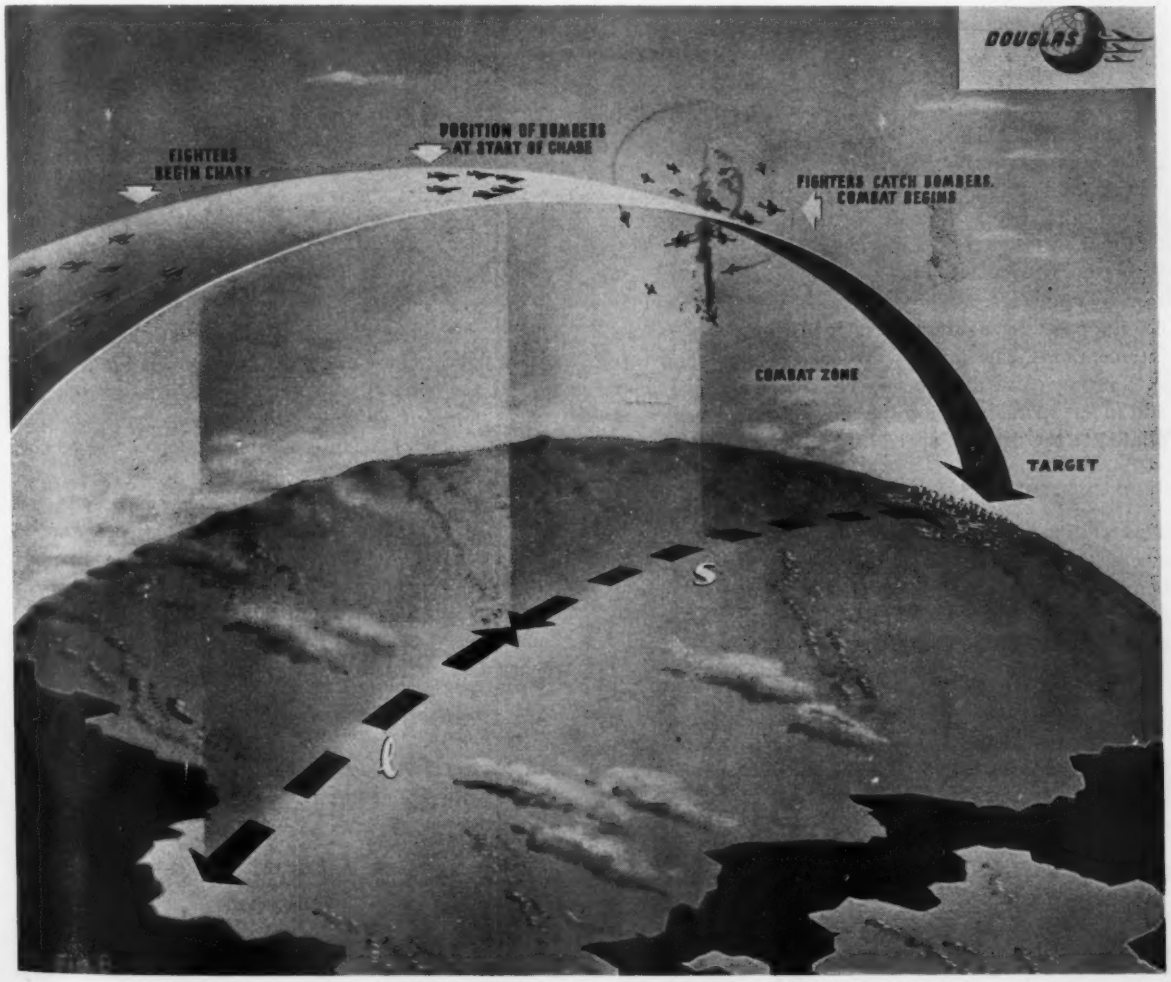
$$t_c = (S/V_B) - [l/(V_F - V_B)] \qquad (1)$$

* A review of the world's literature[11] in the field of high-speed aerodynamics, for example, shows that the basic knowledge on which the design of supersonic airplanes can be based is developed highly in several countries.

† For this example, it is assumed that the important bomber attrition is that which takes place before the target is reached.

It is seen that a double advantage is obtained by increasing the bomber speed. First, the time of vulnerability is reduced; second, the chase is over a longer distance, leaving less of the total time for the combat. The fighters can only make the period of chase shorter and therefore are forced into relatively greater speed increases to hold the combat time fixed. Consequently, each combatant strives to have as high a speed as possible in order to affect, in a favorable way, the combat time and, hence, the probability of success. Higher speed bombers lead to a lesser time of vulnerability and also to a lesser combat time. Higher speed fighters lead to shorter chases and therefore longer combat times.

These statements can be illustrated by a numerical example. Suppose the action begins when the bombers are 1,000 miles from their bomb-release point and when the fighters are then 100 miles directly astern of the bombers. Suppose the fighters have a speed of 600 m.p.h. Under these circumstances, the important time intervals are shown on Fig. 7, as the times vary with the bombers' speed. The important results shown there are tabulated in Table 1 for three bombers having speeds of 300, 500, and 545 m.p.h., the first representing



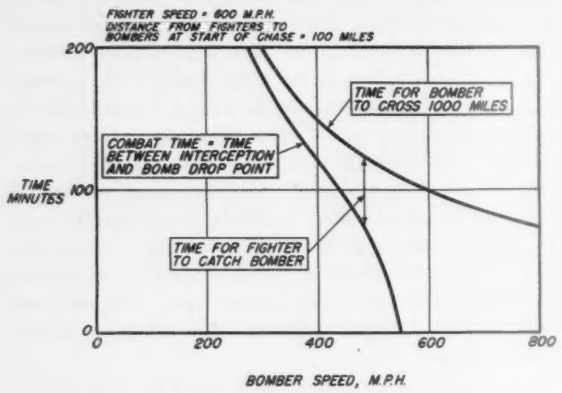


FIG. 7. Effect of bomber speed on combat time.

present-day propeller-driven aircraft and the other two representing jet bombers of higher speeds. The faster jet airplane is studied to show the big gains to be made by using bombers whose speed is fairly close to the fighter speed. The advantage accruing to the faster bomber is clear, and it is of interest to note, for this case, that the combat time is reduced to zero when the bomber is about 10 per cent slower than the fighter.

The discussion above has shown that bombers have enhanced chances of reaching the target as their speed goes up. The fighter also has to be fast in order to do its job well. It can be argued that fast bombers will therefore force the development of extremely fast fighters and, in particular, supersonic fighters. These will probably have relatively short range when operating supersonically. Now, how can one use short-range fighters? This is unquestionably a serious problem. An important alleviating circumstance, however, is seen by again considering the simple tail chase of Fig. 6. Suppose the fighters must go a distance d before interception. The fighters are chasing a moving target; if they chase at higher speeds, they catch it sooner and *in less space*. In fact, the range required to close is related to the fighters' speed by the formula

$$d = l/[1 - (V_B/V_F)] \qquad (2)$$

This relation has been used for the case already studied, where the original distance separating fighters and bombers was 100 miles and where the bomber speed was 545 m.p.h., or roughly 0.8 Mach Number. The results show that a 600-m.p.h. fighter (about 0.9 Mach Number) requires 1,100 miles to close the 100 miles. About 550 miles is needed for the sonic speed fighter to close the gap. Only about 170 miles is required by a fighter capable of flying at 1,325 m.p.h. (Mach Number of 2.0).

An example different from the simple tail chase will now be discussed to show another way in which high fighter speed is important. Consider a line target, such as a coastline. Bombers, having a speed V_B, approach along a line at right angles to the coastline. A radar screen detects these bombers and supplies data in such a way that the fighters take off when the bombers are a distance b out to sea. The fighters, flying at a mean speed V_F, must intercept the bombers over the ocean far enough from the coast to allow a time of combat t_c. This situation is shown in Fig. 8. The airports along the coast must be spaced properly, for a certain fighter speed, or the bombers will be able to penetrate between airports. Now, what is the airport spacing, for each fighter speed, to ensure interception? This is given by the formula

$$V_F = V_B\sqrt{\alpha^2 + t_c^2V_B^2}/(b - t_cV_B) \qquad (3)$$

where α is half the distance between the defending airports. The variation of airport spacing with fighter speed is shown in Fig. 9. The calculations were made for a bomber speed of 545 m.p.h., a combat time of 0.2 hour, and a distance b of 150 statute-miles. Under these conditions, the defending airports are shown to have to lie extremely close together, unless the fighters are capable of supersonic speeds.

This example can be viewed in another way. Where the defense is forced to operate over large spaces and in short lengths of time, then high-speed fighters are vital. From this point of view, Fig. 9 shows that, when a line of defense is being attacked by 545-m.p.h. bombers that are 150 miles from the line at the time of the start of the fighter chase and when 0.2 hour of combat is required, the fighters can solve this problem over the distances noted in Table 2. The distances are measured along the line of defense, perpendicular to the bomber flight path.

The greater usefulness of the supersonic fighter is apparent. This calculation would indicate that a choice exists between faster airplanes and more (and more closely spaced) airports. The faster airplane does have the advantage of solving other combat problems (like the chase for a second pass) which are not influenced by airport location. The slower airplane must

TABLE 1

Effect of Bomber Speed on Bomber Vulnerability

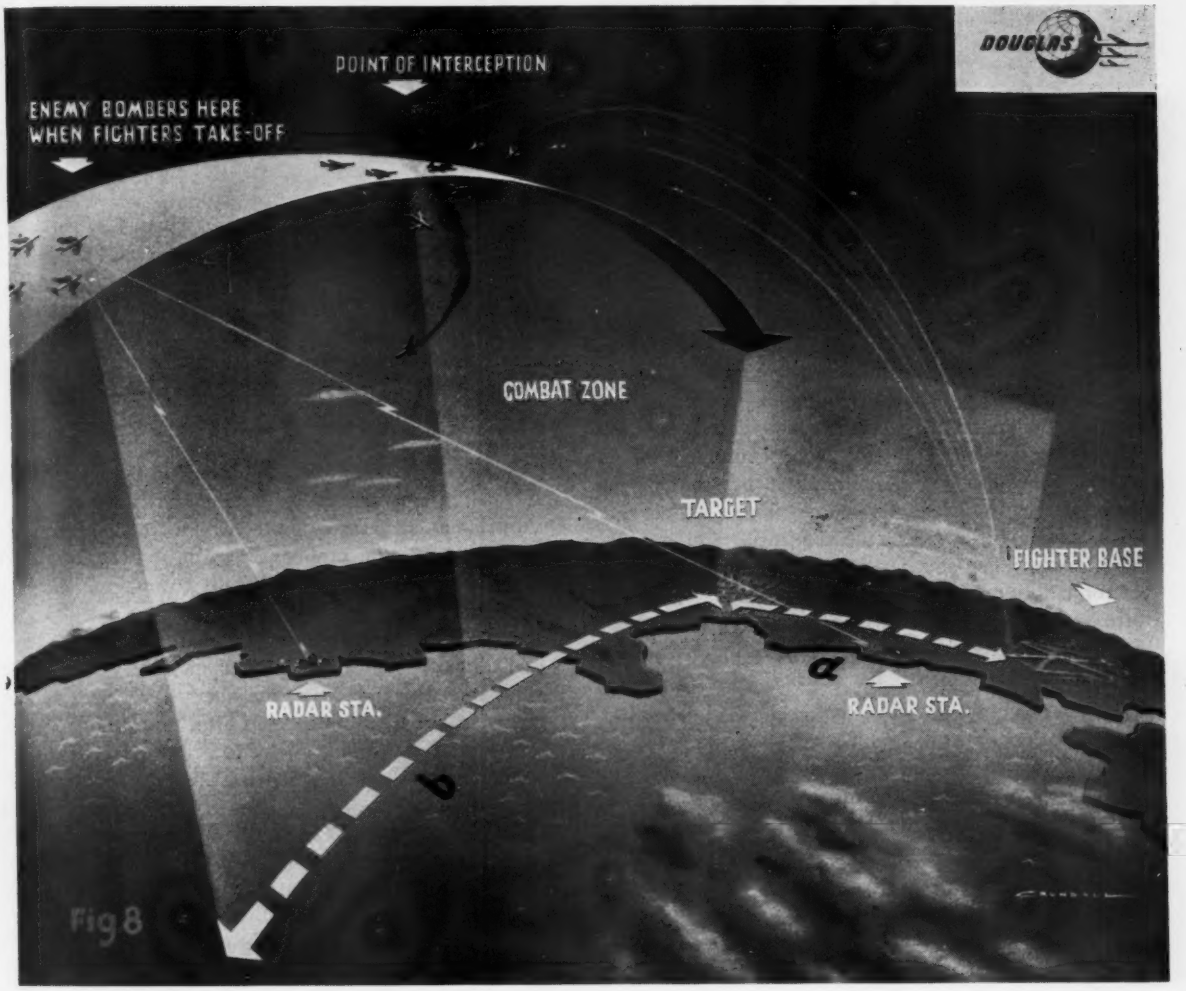
Initial distance from fighters to bombers = 100 statute-miles
Initial distance from bombers to target = 1,000 statute-miles
Fighter speed = 600 m.p.h.

Bomber Speed (m.p.h.)	Time for Bomber to Cross the 1,000 Miles (min.)	Time for Bomber to Reach Target After Interception (min.)
300	200	180
500	120	60
545	110	0

TABLE 2

Effect of Fighter Speed on Usable Fighter Range
Bomber speed = 545 m.p.h.

Fighter Speed		Length of Line of Defense Which Can Be Protected (statute-miles)
M.p.h.	Approximate Mach Number	
600	0.9	60
660	1.0	70
1,000	1.5	135
1,325	2.0	190



be operated from a greater number of airports, at each of which is stationed a fighter group of the same size. This means that the total number of fighters is also increased by virtue of the poor speed performance.

Several idealized combat situations have been discussed to show how military airplanes can advantageously use speed and more speed. There are, of course, other nonmilitary reasons for desiring high flight speeds. In 1911 it was said[3] that "the importance of speed in the development of flying lies in the power which speed gives to an airman in combating a wind." In more recent times, our commercial air lines have gradually increased their speeds; this, coupled with improved safety and schedule reliability and lower fares, has contributed to the welfare and productiveness of our people. Additional reductions in intercity schedule times will add further to the usefulness of the airplane. This will always be true even when the trip time approaches zero.

Conclusion

This discussion can be summarized in several statements. First, it was said that a decade in aeronautical development is a period sufficiently long to encompass great advancements in airplane performance and utilization. Second, it was pointed out that predictions in aviation for a 10-year period are difficult to make and

(*Continued on page 45*)

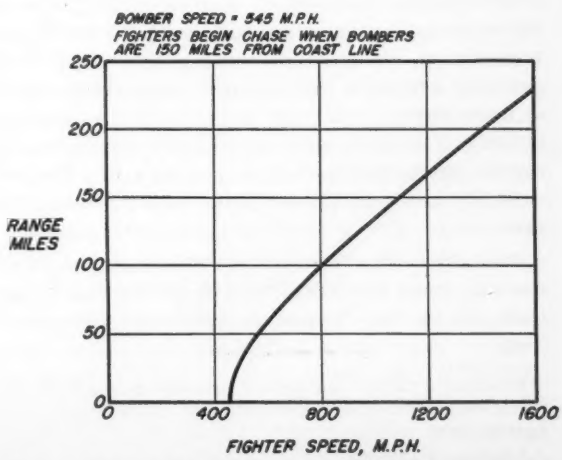


FIG. 9. Effect of fighter speed on fighter usable range and on permissible airport spacing.

The Helicopter Pressure Jet

A Discussion of the Design Considerations Involved in the Use of Pressure Jets in Helicopters

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Introduction

The desirability of departing from the conventional system of shaft-driven helicopter rotors may best be understood by considering that the power plant, transmission, and antitorque equipment of an average helicopter comprise about 30 per cent of the gross weight and, with its great number of moving parts, causes the majority of the initial and maintenance costs. The specific consumption of fuel and oil per rotor horsepower (due to cooling, gearing, and antitorque losses) is about 10 to 15 per cent higher than that of the basic engine and assumes, in hovering, a value of about 0.7 lb. per rotor hp. per hour.

The average pay load of such a mechanical helicopter amounts to about 20 per cent of the gross weight. By replacing the reciprocating engine of such a typical helicopter with one of the turbopropeller type, a saving of about 0.5 lb. per engine hp. would be achieved, reducing the power-plant group weight to about 25 per cent of the gross weight. The fuel consumption in some flight conditions would be somewhat higher, but an increase in pay load of about 20 per cent may be expected.

If it were possible, however, physically to install a jet engine of average performance on the blade tips, the power-plant installation weight would be reduced to about 6 per cent of the gross weight and the specific consumption would be about 1 lb. of fuel per rotor hp. per hour, with chances of improvement in the future. Depending upon desired range, this would allow approximately doubling the present pay load. The initial cost of the complete drive system, based upon $12 per lb. of thrust for the jet engine and $20 per hp. for the engine, transmission, and antitorque combination, would be reduced by a factor of about 2, and a comparable saving in maintenance costs could be achieved. An increase in fuel cost would be encountered, but in the vicinity of specific consumptions of 1 lb. per rotor hp., the fuel costs form an insignificant part of the operating expenses.

It is easy to see how powerfully the costs per pay-load ton-mile would be affected both by the increase in pay load and by the decrease in initial and operational costs.

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* Helicopter Division.

Unfortunately, at the present state of the art it is difficult to install jet engines at the rotor blade tips because of (1) centrific loads on the turbine rotor, (2) gyroscopic loads on the turbine rotor, and (3) gyroscopic loads on rotor blades and control system.

The balance of air and mass forces on the rotor blades in such a manner as to produce satisfactory flight, vibrational, structural, and control force characteristics is one of the main problems confronting the helicopter designer today, and it is difficult to imagine how the powerful gyroscopic moments set up by a tip-located turbine would be eliminated or put to good use without great design and development effort. It is understandable, therefore, that designers have been seeking means either to eliminate the rotating parts of the tip power plant or to find a way to achieve the basic simplicity of the torqueless drive without physically locating a power plant at the blade tip. The first effort has led to the development of ram- and pulse-jet helicopter rotors, while the second trend of thought has brought about a number of systems commonly defined as "pressure jet" drives.

Unfortunately, again, no way has been found to devise a jet power plant, without rotating parts, which has specific fuel consumptions comparable to those of conventional jet power plants at the subsonic speeds to which the helicopter blade tip is apparently confined by aerodynamic, structural, and vibrational considerations. The inherent difficulty lies in efficiently achieving a high enough pressure level prior to combustion without the benefit of moving parts. In spite of this high fuel consumption, however, the extremely low initial and maintenance costs of ram- and pulse-jet helicopters may well permit total operational costs below the ones encountered on present-day mechanical helicopters, and they will therefore find their uses in the field of short-range operations.

The Duct Requirement

On the other hand, the search for pressure-jet systems that make use of a mechanical compressor has led to various solutions. Rather than discuss these systems in detail, an attempt will be made to show the general thermodynamic principles and some aerodynamic considerations that govern the design and limit the attainable performance.

A common feature of all systems employing a centrally located power plant in combination with a

tip-driven rotor is, of course, the necessity of ducting the driving medium, air, through the rotor blades. The propulsive efficiency achieved is

$$\eta_p = 2V_t/(V_j + V_t) \qquad (1)$$

and the usable thrust is

$$T_j = (w/g)(V_j - V_t) \qquad (2)$$

where V_j and V_t denote exhaust velocity and tip speed, respectively, while w is the weight flow of driving air per second.

Eq. (1) shows that the exhaust velocity should be as close as possible to the tip speed for good propulsive efficiency, indicating that low pressure ratios should be used. The second equation shows that, as the first requirement is fulfilled, a larger and larger weight flow of air is required to produce a given amount of thrust. The larger the weight flow and the lower the pressure ratio becomes, the greater the duct cross section required.

On the other hand, the duct that can be provided in the rotor blade without aerodynamic compromise is limited, and it is necessary to sacrifice both propulsive efficiency and aerodynamic performance to arrive at a combined optimum. While the solution of this optimum problem is necessary in every specific design, some general conclusions are possible.

It is desirable first to achieve a maximum amount of rotor thrust T_R for a given amount of jet thrust T_j. Fig. 1 shows, for a typical rotor having a tip speed of 600 ft. per sec., T_R over T_j against the solidity (the ratio of blade area to rotor disc area). Three curves for different disc loadings DL are shown, as well as a line of constant specific blade loadings BL of 0.10, which is considered the highest permissible with regard to maneuvering qualities and blade stall. Conditions to the left of this line, therefore, cannot be used. Fig. 1 shows that the highest rotor thrust for a given jet thrust can be achieved with low solidities and low disc loadings. This would result in both a long and narrow duct. Eq. (1) and (2), on the other hand, showed that as large a weight flow as possible of low-pressure air should be used. The shorter the duct and the greater the cross section, the better the propulsive efficiency.

To find the combined optimum between these contradicting requirements involves a great many variables. Power-plant weight and the variation of specific fuel consumption with pressure ratio must be known, as well as how the blade weights vary with disc load, solidity, duct area, and internal pressure. The mission must be known in order to determine whether an optimum of cost per ton-mile, of speed, of range, or of any other variable is desired, but there will always be a desire to keep the duct small in order to make aerodynamic gains and to save structural weight.

The tendency will therefore be to seek systems that have high thrust for small-volume flow. By combining Eq. (2) for the jet thrust with the definition of volume flow Q,

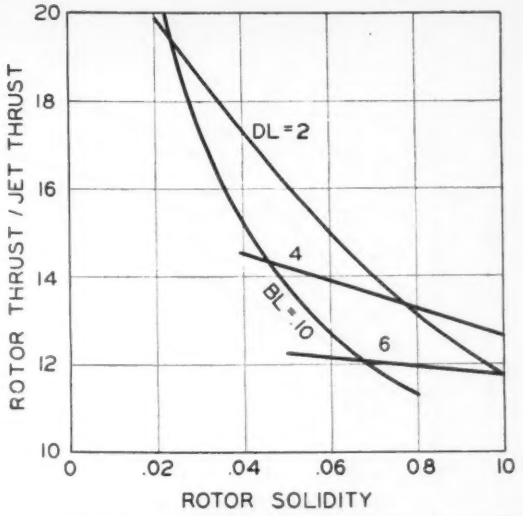

FIG. 1. Rotor thrust per pound of jet thrust vs. rotor solidity for 600 ft. per sec. tip speed.

$$Q = w/\rho g$$

(wherein ρ denotes the density of the air in the duct), it can be shown that the ratio of jet thrust to volume flow becomes

$$T_j/Q = \rho\,(V_j - V_t) \qquad (3)$$

The following trends, therefore, can be followed to increase T_j/Q: (1) to increase V_j and ρ simultaneously by increasing the pressure ratio; (2) to increase V_j alone by burning in the blade tips. A change of temperature prior to entering the blade duct will have little influence on T_j/Q because it decreases ρ as it increases V_j.

Systems Without Tip Burning

Tip burning, in general, will increase the specific consumption by increasing heat losses through the exhaust, just as afterburning does in a turbojet engine. Although it is a powerful means of increasing the jet thrust per compressor horsepower and of arriving at small duct areas, it does not allow specific consumptions comparable to those of turbojet engines, as will be shown later. It is of interest, therefore, to investigate the possibilities of the more efficient cycles that do not resort to tip burning.

Essentially, the problem is now confined to devising an air pressurizing system that meets the following requirements: (1) deliver air to a pressure ratio sufficiently high to meet the duct area requirement, (2) deliver air at a temperature sufficiently low to avoid unreasonable structural problems in the blades and joints, and (3) do this at minimum specific fuel consumption and minimum power-plant weight.

It is difficult to establish limits to the above requirements because of the overall compromise problems mentioned before. With reasonable rotor-blade weights, however, the lower limit to the pressure ratio appears to be around 2:1. The maximum temperature is also hard to establish. The use of temperatures

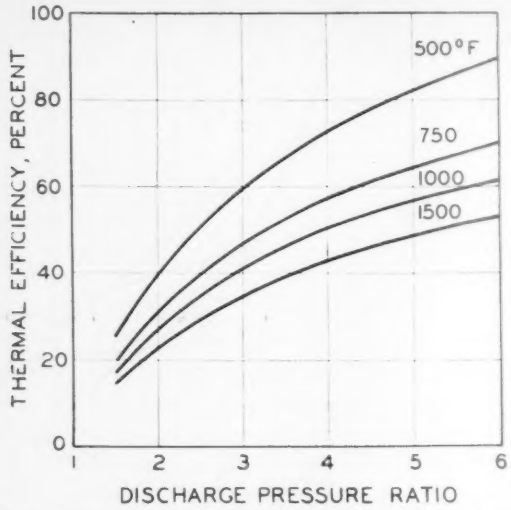

FIG. 2. Discharge temperature vs. discharge pressure for various thermal efficiencies.

above about 1,000°F., however, would certainly result in extreme design difficulties. Even at 1,000°F., the use of most sealing materials and of all aluminum alloys is ruled out completely.

It is helpful to remember that the efficiency of a power plant that takes in air at one pressure and temperature and delivers it at another pressure and temperature is completely defined by this change in condition as long as no heat is withdrawn at any place during the cycle.

For example, if the temperature difference of intake and discharge air would only be equal to the adiabatic temperature rise due to compression from intake to discharge pressure, this would indicate not only that the compressor had a 100 per cent adiabatic efficiency but also that the engine driving this compressor had converted all the energy of the fuel into mechanical work without loss. The efficiency would have been 100 per cent. Conversely, if there were no pressure difference between intake and discharge but a temperature rise were present, the usable work from the discharge air would have been zero and so would the efficiency. It must be remembered that the above is true, regardless of the nature of the cycle that has been followed in bringing the air from the inlet to the discharge condition, as long as the one requirement was met—namely, that no heat was lost during the cycle. This would hold true for a conventional jet engine and also for a reciprocating engine driving the compressor and delivering all its cooling heat and exhaust flow into the discharge air.

Fig. 2 shows a plot of this basic relationship, and it may be seen that a thermal efficiency of at least 27 per cent is required to meet the limiting conditions imposed by rotor-blade considerations. It may also be seen that any increase in efficiency will lead to higher pressures or lower temperatures, along with an obvious improvement in specific consumption. It is astonishing that, for example, at 2:1 discharge pressure ratio, an increase in efficiency from 23 to 27 per cent will decrease the discharge temperatures from 1,500° to 1,000°F.

A reciprocating engine of 35 per cent thermal efficiency driving a compressor of 80 per cent adiabatic efficiency would have an overall efficiency of 28 per cent and would therefore meet the blade requirements even if all heat losses of the engine were used to heat the discharge air. Unfortunately, the jet velocity resulting from a desirable pressure ratio of about 2:1 and from the temperature obtained through the 28 per cent efficient cycle is about 1,700 ft. per sec., making a propulsive efficiency of about 50 per cent when a reasonable tip speed of 600 ft. per sec. is used. For the same rotor power, therefore, the engine would have to be far more powerful than for mechanical drive where at least 85 per cent of the engine output can be transmitted to the rotor. Also, the weight of an additional compressor would have to be carried. Many of the promising advantages of the jet drive would thus be lost.

A turbojet engine of current performance, on the other hand, has a turbine outlet temperature of about 1,200°F. at a pressure ratio of about 1.8:1. Although it could be possible to cool the discharge air to the required 1,000°F. or less, thereby removing heat during the cycle and avoiding the limitations illustrated in Fig. 2, the pressure ratio is still too low. The hope of adapting such an engine by changing its pressure and temperature conditions in such a manner as to achieve higher turbine outlet-pressure ratios is futile because, in general, turbojet designers obviously attempt to get as much thrust per pound of fuel as possible. The air-fuel ratio is limited by the maximum permissible turbine inlet temperature on the high side and by a rapid loss of efficiency on the low side. Therefore, to get much thrust per pound of fuel means to get much thrust per pound of air. This can only be done by the high exhaust velocities that result from high turbine outlet pressures. The hope for higher turbine discharge pressures with given component efficiencies and combustion

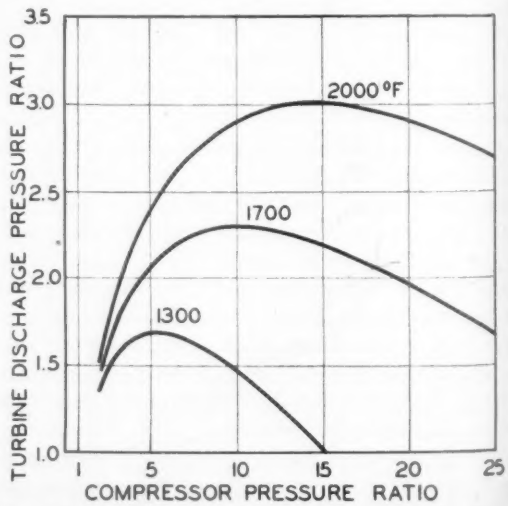

FIG. 3. Turbine discharge pressure ratio vs. compressor pressure ratio for 80 per cent component efficiencies and various combustion temperatures.

temperatures, therefore, is futile because they go along with low specific fuel consumption; consequently, everything possible is being done to achieve this aim. Fig. 3 illustrates this situation. The turbine discharge pressure ratio for various turbine inlet temperatures is plotted against the compressor pressure ratio for assumed component efficiencies of 80 per cent for both compressor and turbine. It can be seen that for each turbine inlet temperature there is a maximum discharge pressure ratio that cannot be exceeded. The compressor pressure ratios at which this peak appears are the ones currently employed because they result in best specific fuel consumption.

Current component efficiencies already run somewhat higher, and turbine inlet temperatures may also increase with the advent of improved turbine-blade design and materials. It can be concluded, therefore, that it will become possible to use a turbojet for direct helicopter propulsion in the future in the following ways:

(1) As soon as turbine discharge pressure ratios exceeding 2:1 are achieved, the basic relationship between efficiency, pressure, and temperature which would still produce temperatures in excess of 1,000°F. could be by-passed by cooling the exhaust. The physical significance of this procedure is to remove the heat that is produced alongside with the available energy (manifesting itself in pressure), which, for poor efficiencies and for the required pressure ratio, brings the flow to a temperature that cannot be allowed in the blade. The specific weight and efficiency of this power plant would be somewhat worse than it was for the basic engine because of exhaust energy loss from cooling. The situation can be somewhat improved by using part of the removed heat in a regenerative cycle, thereby improving the efficiency and having to remove less heat.

(2) As pressure ratios become higher than required, it is possible to effect this cooling by taking out some shaft power—with a consequent reduction of discharge pressure back to the required value—and using this power to compress more air up to discharge pressure and mixing it with the exhaust.[1] During this cycle (Fig. 4A), no heat is dumped, and the basic relationship between pressure temperature and efficiency must be met. The physical significance of this ducting procedure is to transform the turbine discharge air, which is now produced under an efficiency not requiring removal of heat any more, from its high pressure-high temperature exhaust condition (resulting from an efficient cycle) to the desired lower temperature and pressure level dictated by blade and propulsive efficiency considerations. Fig. 2 shows that an efficiency of about 27 per cent must be achieved, corresponding to a specific fuel consumption of about 0.57 at 600 ft. per sec.

It can be seen, therefore, that jet engines become increasingly adaptable to helicopter propulsion as their performance is improved, because low specific consumption is fortunately achieved with the same turbine outlet conditions that lead to small duct area—namely, high pressure and low temperature. Power plants that appear relatively small even in a fighter that weighs

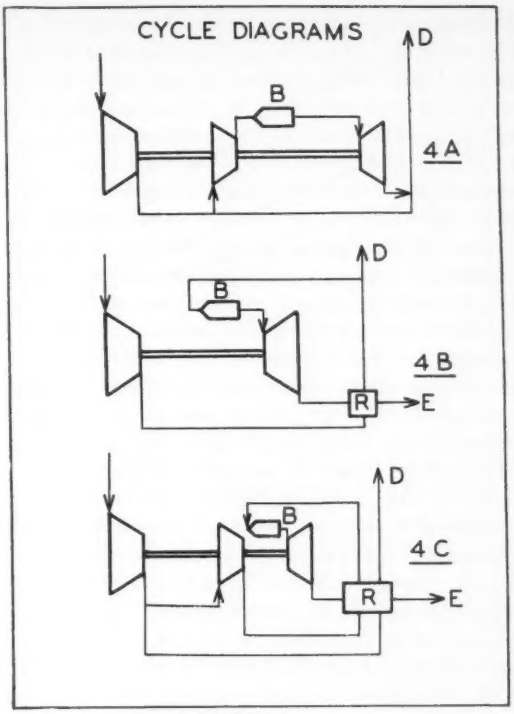

FIG. 4. Cycle diagrams.

about three times as much as the thrust of the engine can then be used to power helicopters weighing twelve to 15 times the engine thrust, with the encouraging results quoted in the Introduction.

On the other hand, an undesirable effect of the great load that a relatively small gas turbine can carry is that extremely small power plants will be needed to power average-size helicopters. There is little incentive to develop such power plants except for helicopter propulsion, and it may also be expected that they would show less efficiency than their bigger counterpart. While it appears marginally possible to reach the low specific consumption of around 0.57 lb. per hour per lb. on a ducted jet engine of considerable size, it is believed unlikely that engines suitable for propulsion of middle-size helicopters will reach that stage within the foreseeable future. It is worth while, therefore, to investigate the possibilities of avoiding the above-mentioned basic difficulties by departing from the conventional thermodynamic cycle.

If it is assumed that the component efficiencies of small compressors and turbines will not exceed a value of 80 per cent and that turbine inlet temperatures of over 1,600°F. cannot be used, the turbine discharge pressure will hardly be sufficient to feed into the rotor. The rotor air, therefore, should be taken out from in front of the turbine and, for temperature reasons, also from in front of the burner. The turbine discharge will then be of atmospheric pressure (or slightly less when a

diffuser is used), permitting bleed-off percentages of up to 50 per cent. It is now obvious that the turbine exhaust air carries away a substantial amount of energy in the form of heat that could be put to good use in preheating the turbine air prior to combustion or the rotor air, or, preferably, both.[2] Fig. 4B illustrates such an arrangement. While for the conventional turbojet engine regeneration is of doubtful value (because as it decreases the fuel flow to the burner it also decreases the jet thrust by cooling the exhaust flow prior to expansion), it is definitely worth while in this case because as it decreases the fuel flow it also increases the thrust by increasing the temperature of the working medium. This system offers considerable flexibility because it allows free choice of air pressure and temperature inside the rotor blades, but it has the disadvantage of not permitting direct usage of available power plants. It should be noted, however, that a small gas turbine for the starting of large jet engines has recently been developed which operates on the same principle, shown in Fig. 4B, employing a flow of preheated compressor bleed air to energize the main turbine.

Fig. 5, Curve A, shows the specific consumption in pounds of fuel per pound of rotor tip jet thrust obtainable by this system, plotted over the compression ratio across the compressor. (Curves are shown for component efficiencies of 80 per cent, a turbine inlet temperature of 1,470°F., and a rotor air temperature of 660°F.)

It is of interest to note that pressure ratios in excess of 2:1 bring little improvement. This fact is brought about by the decrease in propulsive efficiency occurring at higher pressure ratios simultaneously with an increase in thermal efficiency. A considerable improvement could be achieved by installing more than one compressor stage and by bleeding rotor air at a low-pressure stage, thus increasing the thermal efficiency without decreasing the propulsive efficiency (Fig. 4C). Here again, power-plant weight and cost must be weighed against the reduction in fuel load and fuel cost.

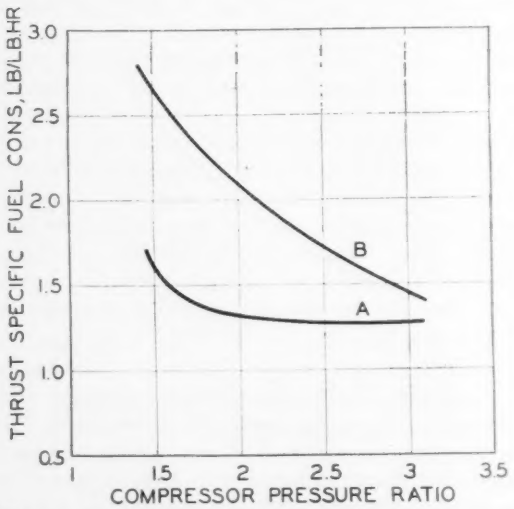

FIG. 5. Specific consumption of bleed-off regenerative cycle (A) and conventional turbojet (B) vs. pressure ratio for 600 ft. per sec. tip speed, 1,470°F. combustion temperature, 660°F. regenerator outlet temperature, and 80 per cent component efficiencies.

In Fig. 5, Curve B, the specific consumption of a conventional turbojet of equal component efficiency and turbine inlet temperature has been plotted for comparison. It may be seen that the conventional cycle continues to reduce its specific consumption with increasing pressure ratio, because here the exhaust velocity is lower, delaying the detrimental effect of high pressure ratios upon propulsive efficiency. However, even at 3:1 pressure ratio, the consumption is still higher than that of the regenerative bleed-off cycle.

It may be concluded, therefore, that it is entirely possible to devise thermodynamic cycles that will permit a combination of limited component efficiencies, low temperatures, low fuel consumption, and suitable rotor drive air conditions. The installed weight of such a power plant would be considerably higher than that of a conventional jet engine because of lower specific thrust and the addition of a regenerator. The most serious deterrent to developments of this sort, however, is the high cost involved in developing, or considerably modifying, a power plant for specific helicopter purposes.

TIP BURNING

To increase the temperature of the rotor drive air by means of a tip burner (prior to expansion but after passage through the rotor blades) will always be associated with an increase in thrust specific fuel consumption because it increases the heat losses through the tip exhaust. On the other hand, it allows the thrust to be boosted considerably above the value obtained without burning. This increases the thrust per unit volume flow [Eq. (3)] and decreases the required compressor horsepower per pound of jet thrust and, consequently, per pound of gross weight. Tip burning is therefore advisable in the following cases:

(1) Tip burning is desirable if it is desired to boost the thrust of a turbine installation in a helicopter temporarily for overload take-off or high-altitude hovering, or (in the case of multi-engine installation) to permit hovering after failure of part of the power sources. In cruising, of course, such an installation would have essentially the same specific consumption as the basic system discussed in the previous paragraphs. A slight reduction in normal performance will be caused by the pressure drop associated with the installation of a flame stabilization device. This situation is comparable to turbojet thrust augmentation by afterburning.

(2) Tip burning is desirable if reasons of power-plant availability or development cost dictate the use of a compressor system that is basically a poor pressure-jet drive system. It will, in this case, reduce the relative size of the installed power plant and the relative importance of its efficiency. This flexibility in the choice of the power plant is achieved again under penalty of total thrust specific consumption.

(3) Tip burning is desirable if the aircraft to be designed depends upon rotor drive only for hovering and cruises with the rotor in autorotation. Here, the importance of low thrust specific consumption is greatly reduced because of the small amount of hovering time per total flight time, and the rotor should be almost uncompromisingly designed for forward flight, making for small duct areas that, in turn, can be achieved much easier with tip burning.

For reasons of power-plant availability, all pressure-jet helicopters built or under active consideration today have resorted to tip burning. The only two of these helicopters to have reached the flight-test stage, the Austrian WN 342[3] and the French SO.1100,[4] were designed to cruise in autorotation. Once the penalty of a heavy reciprocating, but easily available, power plant was taken, it was obvious, in order to avoid further penalties from high fuel consumption, to go into autorotation in cruising. This can be simply achieved by disconnecting the engine from the compressor it drives during hovering and coupling it instead to a conventional propeller.

Fig. 6 shows, again for a tip speed of 600 ft. per sec., the thrust-specific fuel consumption over the tip-burner combustion temperature for a typical installation. The curves are drawn up to 4,000°F., in the vicinity of which the stoichiometric limit is reached. A conservatively estimated pressure loss and combustion efficiency have been included. It has been assumed that the compressed air is supplied from an 80 per cent efficient compressor driven by an engine having a consumption of 0.65 lb. per hour per compressor hp.; this figure takes power losses from engine cooling and transmission into account. This would also be approximately correct for a modern turbopropeller engine, requiring no cooling fan and no transmission and having the added advantage of lighter weight.

It can be seen that the specific consumption is higher than that of a turbojet engine, even at the lowest combustion temperatures where the nonburning system is reached. This is caused by the fact that an engine-compressor combination with exhaust into the atmosphere was assumed which is essentially a poor thrust-producing machine, because all the heat losses of the engine go to waste while they are employed to increase the thrust of the nonburning systems. Furthermore, it may be seen that at low pressure ratios, and especially at high combustion temperatures, the specific consumption becomes extremely high, resulting from the high weight flow and, consequently, fuel flow required to produce a unit amount of thrust at low pressure ratios.

With higher pressure ratios, gains can be made only within limits, because then the propulsive efficiency becomes low and, consequently, large compressor horsepower, with resulting large compressor fuel flow, is required. This situation may be seen in Fig. 7, where, for 2,540°F. and 600 ft. per sec. tip speed, the burner and compressor engine thrust-specific consumption, as well as the total specific consumption, is plotted against pressure ratio.

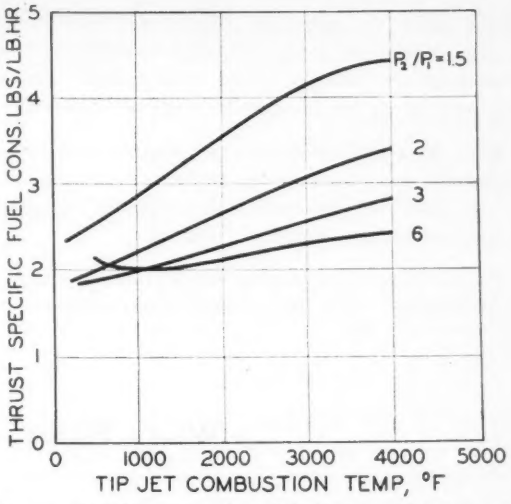

FIG. 6. Specific consumption of tip burner cycle vs. tip combustion temperature for 600 ft. per sec. tip speed and various pressure ratios.

It may be concluded, therefore, that tip burning can be used advantageously for power boost over the normal hovering power or to reach hovering power when reasons of power-plant availability and weight lead to the selection of a small compressor and engine arrangement or, finally, when hovering power is required only for short periods of time and, consequently, the emphasis is laid more on an aerodynamically efficient and structurally light autorotative cruising rotor, with resulting small ducts, than on low hovering consumption.

CONCLUSIONS

The inherent characteristics of pressure jet drive systems for helicopters have been reviewed. It is found that low specific consumption of jet engines is achieved under the same set of conditions that make the turbine discharge air suitable for ducting through rotor

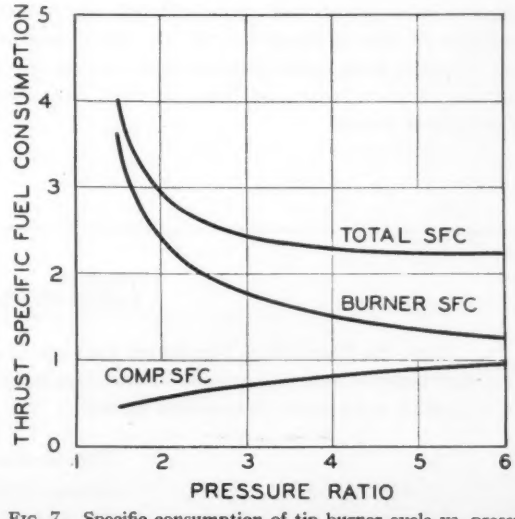

FIG. 7. Specific consumption of tip burner cycle vs. pressure ratio for 600 ft. per sec. tip speed and 2,540°F. tip combustion temperature.

blades prior to expansion. Extremely low specific consumption must be reached before satisfactory blade conditions are brought about, and exhaust cooling, regeneration, or turbine ducting must be employed.

Even with inefficient basic jet engines, satisfactory blade duct conditions can be achieved by modification of the cycle, but power-plant development for specific helicopter purposes would be required.

Use can be made of existing power plants by resorting to tip burning. Low fuel consumption is sacrificed, but significant gains can be made for rotary-wing aircraft in which rotor propulsion is called upon for only short periods of the total flying time.

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What's Wrong with Today's Helicopters?

(*Continued from page 29*)

normal production efficiencies and further by the application of high-volume machine tooling.

Conclusions

We are actively working on all of the above major categories of improvement, and I am sure every other company in the industry is giving its full consideration to these problems When the research now being done can be brought to fruition, production answers to these deficiences will be ready in the next few years. The Government can be of great service in the acceleration of the development of these improvements by increasing the standards of its criteria both for performance and for reliability testing. In the latter, it can actively participate by checking and proof-testing the manufacturers' output.

Military needs for the helicopter are ever increasing. The Navy's prime function of antisubmarine warfare shows the need of the helicopter's flight characteristics. Even Coast Guard off-shore rescue work, where long ranges are involved, has demonstrated the superior qualities of the helicopter over all other methods. The Marines have established a new concept of amphibious warfare with the few transport helicopters now in their hands.

The Army plans call for liaison and supply functions to be accomplished by the helicopter. There is a great demand for rotary-wing aircraft in Air Force Arctic Rescue operations. In many cases, it is the only vehicle capable of performing such missions. Front-line supply and transport by helicopter are at present in Air Force and Field Force plans.

Commercially, Los Angeles Airways has built a fine helicopter operation record in the past $2^1/_2$ years. The Helicopter Air Service in Chicago has proved its success in the past year, and New York City awaits C.A.B. go-ahead to inaugurate its helicopter service with passengers this year.

British European Airways has already started scheduled passenger runs on their helicopter route between Liverpool and Cardiff. On June 10, 1950, Sabena Airlines opened a helicopter mail service in Brussels.

Oil prospecting, crop dusting, and topographic surveys are but a few of the special industrial uses of the helicopter that are expanding.

When the more serious criticisms that have been discussed herein are satisfactorily met by the helicopter industry, the number of applications of this versatile transport vehicle will multiply, requiring a production volume without precedent in the peacetime aircraft industry.

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Technical Sessions—Annual Summer Meeting

(*Continued from page 25*)

C. A. Meyer and **H. F. Faught,** Westinghouse Electric Corporation, in their paper on "A Method of Presenting the Performance of Turbojet Engines" have reviewed the history of turbojet performance analyses. Their paper points out a number of problems that were involved in methods that have in the past been used for analyzing results of turbjoet engine performance testing. The difficulties accounting for such performance variables as compressor air bleeding and additional power extraction from the gearbox are discussed. A newly developed correction factor method for analyzing turbojet engine performance is then described in detail. This method consists of applying a number of formulas to test results in order to obtain corrected values. Although the formulas are extensive, the authors point out that only the regions of the performance curves which are of interest need be corrected.

The formulas themselves account for corrections in the following six variables: (1) inlet duct loss, (2) exhaust duct loss, (3) air bleed, (4) power exhaustion, (5) ambient temperature variation, and (6) turbine inlet temperature variation.

TABLE 1

Assumed Change	Ratio of Correction Factor Thrust to Cycle Thrust	Ratio of Correction Factor Fuel Flow to Cycle Fuel
Duct loss $\Delta p_{t2}/p_{t2} = 20\%$	0.982	1.000
Power ext. ($hp_{ext.}/hp_{ref.}$) = 20% (150 hp. for 4,000-lb. thrust)	1.000	1.000
Air bleed ($w_{bl.}/w_a$) = 10%	0.991	1.008
Ambient temperature $\Delta T_{am.} \div T_{am.} = -24\%$ (59° to −67°F.)	1.017	1.000

The authors have given a table in order to provide some idea of their correction factor method. This table (Table 1 herein) gives the ratios of the thrusts and fuel flows obtained by (a) correcting the no-loss cycle results and (b) by an independent cycle calculation in which the particular loss is assumed. As the authors point out, the losses shown are the extreme values to be expected in practice.

The paper by Messrs. Meyer and Faught completed the Technical Sessions of the 1950 I.A.S. Annual Summer Meeting.

I.A.S. National Meeting Schedule

Wright Brothers Lecture—U. S. Chamber of Commerce Auditorium, Washington, D. C.—December 16

Nineteenth Annual Meeting—Hotel Astor, New York, January 29–31, February 1, 1951

Members or organizations wishing to submit papers for presentation at National Meetings should send outlines or summaries to the Committee no later than 5 months prior to the meeting.

All papers submitted will be considered for publication in the *Journal of the Aeronautical Sciences* or the *Aeronautical Engineering Review.*

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A Guest Editorial

(*Continued from page 15*)

Force-of-the-future, so that the operational striking power of our force-in-being would continually improve under the dynamic stimulus of science and technology. In addition, the Chief of Staff appointed a special group, under General Kenney at the Air University, to study the strictly military aspects of the problem.

"Many recommendations made in the resulting two studies have already been implemented. Two major ones, the formation of a Research and Development Command under General Schlatter and the creation of the office of the Deputy Chief of Staff, Development, have been announced in the press.

"We all realize that the shifting around of a few boxes on an organization chart does not by itself solve any problems. However, the location of the R&D boxes on the present Air Force organization chart gives a clear indication of the emphasis that the Country's air arm places on this important function.

"The Deputy for Development ranks with the Deputies for Operations, Comptroller, Personnel, and Materiel and reports directly to the Chief of Staff. The creation of this office ensures the forceful impact of research and development on *top-level Air Force planning*.

"The Research and Development Command, which is separate from, and independent of, the Air Materiel Command, is the field agency that will have primary cognizance over all *research and development operations*.

"A separate Research and Development Command does not mean insulation of the development effort from production and maintenance problems. We want a strong interaction there. At the same time, our planners feel that the evolution of future weapons should not be too deeply submerged among the logistics activities of the present force-in-being.

"This Air Force research and development structure must continually answer the question: 'Where are we going?' The resources of the Nation are not unlimited. We can no longer purchase two each of everybody's new idea and try it out. The technological possibilities in military science today are so complex, so expensive, and so far reaching that some method of discrimination, based on quantitative evaluation, is needed prior to the writing down of requirements directive or 'military characteristics.' This 'quantitative evaluation' involves consideration by tacticians in terms of military worth and by technicians in terms of scientific effort required to develop a new idea successfully. The end result of this process of quantitative evaluation is the planning and implementation of the qualitative development of the Air Force. It is, in effect, the 'statement of the problem.'

"I like to think of our work in this evaluation area as 'requirements research.' Under this heading, we group the activities of The RAND Corporation, Project CHORE, and various other design and study contracts with which many of you are familiar. All of these projects must fit into a comprehensive and integrated pattern. The work itself must be based on a set of consistent assumptions which are technically sound and acceptable to the Air Force from an operational point of view.

"Our ultimate objective is a degree of research and development program stability which we have never had before. Along with that, we hope, will come an elimination of the frustration and inefficiency associated with rapid successions of project initiation and cancellation. We can have and must have a sound, long-range plan that is consistently adherred to."

Development *FOR* the Air Force

"Having determined 'where we are going,' we must now answer the corollary question: 'How do we get there?'

"From a policy point of view, the Air Force is in complete accord with the National Aeronautical Research Policy. Essentially, this policy states the following: Fundamental research in the aeronautical sciences is the principal objective of the National Advisory Committee for Aeronautics; the function of industry is the application of research results to the design and development of superior aircraft and equipment; the role of the using agencies—in this instance the military services—is the evaluation and exploitation for possible military use of the resulting items of equipment.

"I would caution, however, against too rigid an interpretation of this policy. The most refreshing thing about research and development is that nothing is ever strictly black and white. By its very nature, creative effort resists strict boundaries and rigid channelization.

"From a practical point of view, the Air Force recognizes that the great reservoirs of scientific and engineering talent in this country remain among the competitive industrial staffs which you members of the Institute represent.

"In our efforts to do better in the development area, it seems to us that we must make better use of your talents. You are generally guided in development work for the Air Force by 'specifications' for the desired airplane or equipment. Many times in the past, you have developed an airplane to meet 'specifications' precisely, only to have the Air Force find that the airplane did not, in fact, do the job for which the 'specifications' were written. In other words, we have sometimes been guilty of telling you the answer instead of posing the question.

"The complete answer to the question 'where are we going?' consists of a series of development problems. 'How do we get there?' or the solution of these problems

is the development *for* the Air Force for which we must depend on you. We are proposing to stop masterminding this part of your business and let you give us the answers.

"Our first attempt at this took place recently. The broad aspects of our major problems were outlined to the industry with a minimum of restrictive requirements. Industry was asked to suggest the most practical solutions that the state of the art would permit. On its first trial, this technique has worked out very well, both in orienting our own thinking on the one hand and stimulating industry's participation on the other.

"The Air Force needs all of the help it can get in increasing the effectiveness of its development work. I therefore earnestly solicit your personal ideas and comments on our methods, procedures, and techniques.

"I have told you about some of our thinking about development *of* and *for* the Air Force. I want to emphasize, at this point, that armed force alone can never ensure for us a peaceful future. In the final analysis, this can only be done by convincing our potential enemies that our way of life is best and that domination of the world by any single group is both unnecessary and undesirable. It is absolutely essential, however, to provide the necessary armed forces that will buy us the time needed to accomplish this.

"From the Wright Brothers to the von Kármáns, the Kindelbergers, and the Arnolds, the unequaled striking power of your Air Force has been fashioned by the creative effort of free men. Ours is the task of maintaining and continually developing that strength so that we may continue to be free."

Some Speculations on the Next Decade in Airplane Development

(*Continued from page 35*)

that this, together with other circumstances, can cause a country to lose its aviation leadership. Third, the basic importance of speed in various combat operations was said to make competition inevitable in the development of airplanes of superior performance, a rivalry that might be fatal to the loser. What can be said now about the next decade? Possible performance improvements have been discussed, gains that can provide tactical supersonic airplanes. In this country, the technological basis for these gains already exists because of jet power-plant developments pioneered by Britain, the monumental research airplane program of the U.S. Air Force, and the research activities of the National Advisory Committee for Aeronautics.

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I.A.S. Nineteenth Annual Meeting

Authors wishing to have papers considered for presentation at this meeting should submit outlines or short abstracts to the Meetings Committee, 2 East 64th St., New York 21, N.Y., no later than September 15, 1950.

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I.A.S. Previews

Summaries of Current Papers Accepted for I.A.S. Publications

Buckling Load of a Stepped Column

By

Frederic M. Hoblit

Lockheed Aircraft Corporation

A procedure is developed for computing the critical buckling load of a column having a finite number of steps with constant *EI* within each step. The procedure is applicable to columns with any end conditions and with loads applied within the span, as well as at the ends.

An Approximate Method for the Calculation of the Stresses in Sweptback Wings

By

Thorkild Rand

Royal Institute of Technology, Stockholm, Sweden

An approximate method is proposed to eliminate the error that arises when groups of stringers are replaced by a few imaginary longerons in order to reduce the number of statically indeterminate quantities in monocoque structures. The idea underlying the method is to choose arbitrarily a limited number of degrees of freedom of motion and to consider the corresponding self-equilibrating groups of forces as the statically indeterminate quantities. A worked-out example shows how nine suitably chosen groups suffice to calculate the stresses in a wing that has 27 statically indeterminate quantities according to the shear field theory. The method suggested was applied to the calculation of the stresses in a full-scale wing that was tested. Good agreement was found between theory and experiment.

Methods for Calculating the Flow in the Trefftz-Plane Behind Supersonic Wings

By

P. A. Lagerstrom and Martha E. Graham

Douglas Aircraft Company, Inc.

By means of the linearized nonviscous theory, methods are developed, using the complex functions of conical flow, for finding downwash and sidewash in the Trefftz-plane—i.e., at an infinite distance downstream, behind a supersonic wing. Equations are derived which describe this flow field behind several types of "flat plate" wings: the wide delta wing, the trapezoidal wing (wide delta wing with cutoff tips), and the delta control surfaces (a narrow delta wing, the two sides of which are deflected differentially). Graphs are included which show the results for these cases.

As observed previously in connection with other cases, in the plane of the wing the flow field is characterized by infinite upwash straight behind the wing tips and, in the case of the delta wings and control surfaces, by a region of constant downwash behind the wing. These conditions are modified immediately upon moving above or below the plane of the wing. It is found that the flow field behind the delta control surfaces, the two sides deflected equal amounts in the opposite direction, does not vary with changes in Mach Number.

In applying the results presented here, one must, of course, take into consideration corrections due to effects of fuselage interference, nonlinearity, viscosity, etc. These effects are, however, not the subject matter of this paper.

On Some Special Problems in Linearized Axially Symmetric Flow

By

Bertrand des Clers and Chieh-Chien Chang

The Johns Hopkins University

In view of the considerable amount of material published on the linearized treatment of axially symmetric flow, both on the subsonic and the supersonic régime and because of the complexity of the results, it was thought advisable to work out an example that, by its very simplicity would give a basic "feeling" for the behavior of bodies in axially symmetric flow.

An infinitely long body with sinusoidal corrugations was considered, and the first part of this work deals with the study of this body immersed in both purely subsonic and purely supersonic flow, whether in or out of wind tunnels, etc. The second part of the work considers the interaction of concentric annular regions of subsonic and supersonic flow around the same body. The case of a subsonic region is investigated in detail because of its resemblance to the supersonic boundary layer. Whenever deemed necessary, the results were compared or extended to the two-dimensional case by letting the radius of the body become infinite.

Some interesting results are obtained, such as wind-tunnel corrections, deviations from the $1/\sqrt{1-M^2}$ two-dimensional Prandtl-Glauert compressibility correction, and the fact that the pressure distribution of an axially symmetric body in supersonic flight is no longer proportional to the local slope of the body but lags behind it by an angle that is a function of free-stream Mach Number and body radius. This lag has already been observed in particular problems worked out by the Fourier integral method, such as the minimum drag body problem of thin bodies of revolution. It is also found that the wave drag is finite at a Mach Number of unity, as was deduced by von Kármán in 1935 for a similar body. The boundary-layer analogy also shows a few interesting results and, particularly, the effect of the thickness of the subsonic region on the wave drag and pressure distribution of the body.

It is shown briefly in an example how the whole procedure can be extended to a more general axially symmetric body and to any number of concentric annular flows, whether supersonic or subsonic.

The Flow over a Wedge Profile at Mach Number 1

By

G. Guderley and H. Yoshihara

Air Materiel Command

The flow over a wedge-shaped profile at zero angle of attack and with a free-

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stream Mach Number of 1 is computed using the hodograph method as simplified by the transonic law of similarity. Drag coefficients are computed for several profiles.

Sphere Drag Data at Supersonic Speeds and Low Reynolds Numbers

By

E. D. Kane

University of California at Berkeley

Drag forces on spheres have been measured in a low-density supersonic wind tunnel. Mach Numbers were from 2.1 to 2.8, and the Reynolds Number (based on free-stream properties and sphere diameter) ranged from 15 to 800. Available experimental data for the same Mach Numbers as the present tests, but with Reynolds Numbers in the order of magnitude 10^6, showed that the drag coefficients could be correlated as a function of Mach Number alone and were not altered by a six-fold change in Reynolds Number. The present data showed an increase of drag coefficient by a factor of $2^1/_2$ over the test range. Flow visualization photographs indicated a possibility that interaction occurred between the sphere boundary layer and shock wave at low Reynolds Numbers.

Additional experimental data are required before the relative importance of viscous, molecular flow, and shock-wave effects can be evaluated completely.

Chanute Award for 1950

(*Continued from page 5*)

permit flying boats to operate in seas far too rough for small surface craft. He has incorporated, in an internationally accepted manual, the conclusions of his research on cross-wind, cross-swell, and other means of executing a safe landing in big flying boats at sea.

Commander MacDiarmid was born in Franklin, Pa., in 1906. He enlisted in the Navy in 1923, and 3 years later he entered the U.S. Coast Guard Academy. He won his wings at Pensacola in 1938 and was immediately assigned to Search and Rescue and antisubmarine patrol duties. He has received the Air Medal and the Distinguished Flying Cross and was appointed the first Coast Guard member of the N.A.C.A., Seaplane Sub-Committee.

The Octave Chanute Award was established by the Institute in 1939 to honor the memory of Octave Chanute, Pioneer American aeronautical investigator, who died in 1910.

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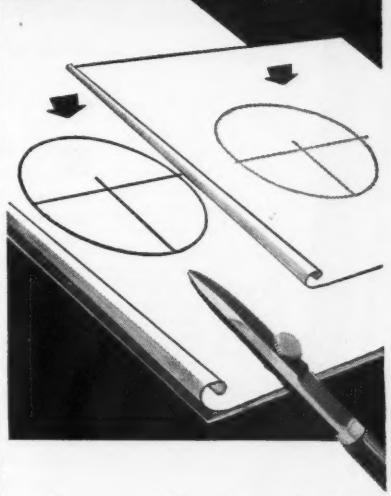

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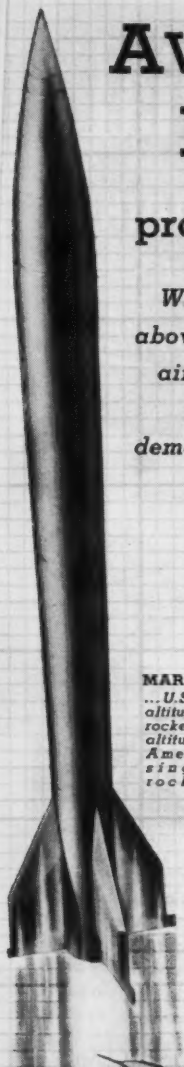

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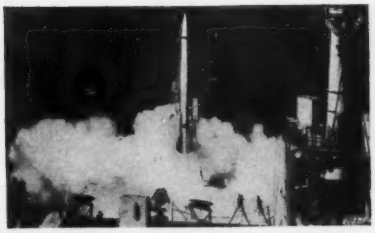
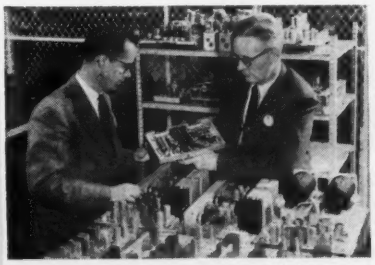


New Rocket Record . . . On May 11, a Navy Martin Viking zoomed 106.4 miles into the upper stratosphere from the deck of the U.S.S. *Norton Sound* in the Pacific, setting a new altitude record for an American-built, single-stage rocket. Reaching a top speed of 3600 m.p.h., the Navy rocket carried intricate instruments which recorded data about cosmic rays for future study. The information was flashed back to the ship by an automatic radio transmitter in the missile.

This was the first time that the Martin Viking, largest U. S. upper atmosphere research rocket, had been fired from a ship, a Navy seaplane tender converted into an experimental guided missile ship.

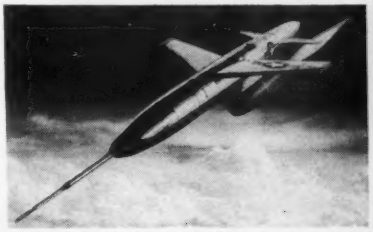
World Safety Mark . . . U. S. flag airlines operating internationally set a new world safety record on April 14, by completing two years without a single passenger fatality. During the two-year period, the American air carriers flew nearly three million passengers approximately four billion passenger miles, also a world record for airlift. The carriers operate 203,678 route miles internationally, serving 239 foreign points on all continents.



Aircraft Design Advances . . . With piloted aircraft following guided missiles past the sonic barrier, man's physical limitations are creating new problems for aircraft designers who must give him the assistance of mechanical and electronic senses, muscles and nerves! To meet this challenge, Martin engineers are designing aircraft as integrated airborne systems, not merely as flying vehicles whose sole goal is speed. In this *systems engineering*, Martin designers work with all three elements that go to make up a complete, modern airplane or missile—airframe and power plant, electronic flight and navigational controls and military armament or passenger facilities. And the complete development is so scheduled that the end product represents a completely coordinated system.

Wind Speeds exceeding 7500 miles per hour, surpassing anything ever dreamed by prewar air scientists, have been obtained in a new wind tunnel announced by the Naval Ordnance Laboratory at White Oak, Md. Penetrating for the first time in history into mysterious realms known as "hypersonic," the new tunnel is regarded by government scientists as the first step in basic research which may some day lead to scientific machines which will girdle the globe in minutes and open the far reaches of the universe to man.

Jet Trainer . . . A new model of the wartime Link Trainer has been okayed by the U. S. Air Force to combine ground training in flight, engine and radio navigation of high-speed jet planes. Rates of roll, climb and acceleration are faithfully duplicated and controls are loaded so pressures vary with air speed. An integral part of the new trainer is emergency controls with which a check pilot behind the cockpit can introduce a variety of operating troubles. The instructor can make the fuel pump or hydraulic system fail, stir up a thunderstorm, have a fuel tank punctured by flak, or create any other flying hazard.



Pilotless Aircraft, flying an evasive course with the speed and maneuverability of jet fighter planes but controlled from afar by radio, will soon be testing the Navy's big antiaircraft guns. The aircraft will be Martin KDM-1 pilotless target drones, several of which have already been delivered for fitting into the "mother" airplane which will carry them aloft for launching. The KDM-1's are the result of successful flights made by the Gorgon IV pilotless aircraft which was designed and built by Martin in cooperation with the Navy to test the possibilities of the ram-jet engine.

The KDM-1's, which have a wing span of only 10 feet, are released at the desired altitude from a pylon near the wing tip of the "mother" airplane. From then on, they fly on their own ram-jet power, controlled from afar by radio while being watched on a radar screen. Controls may be preset before launching, but may be overridden by radio at the discretion of the distant control officer.

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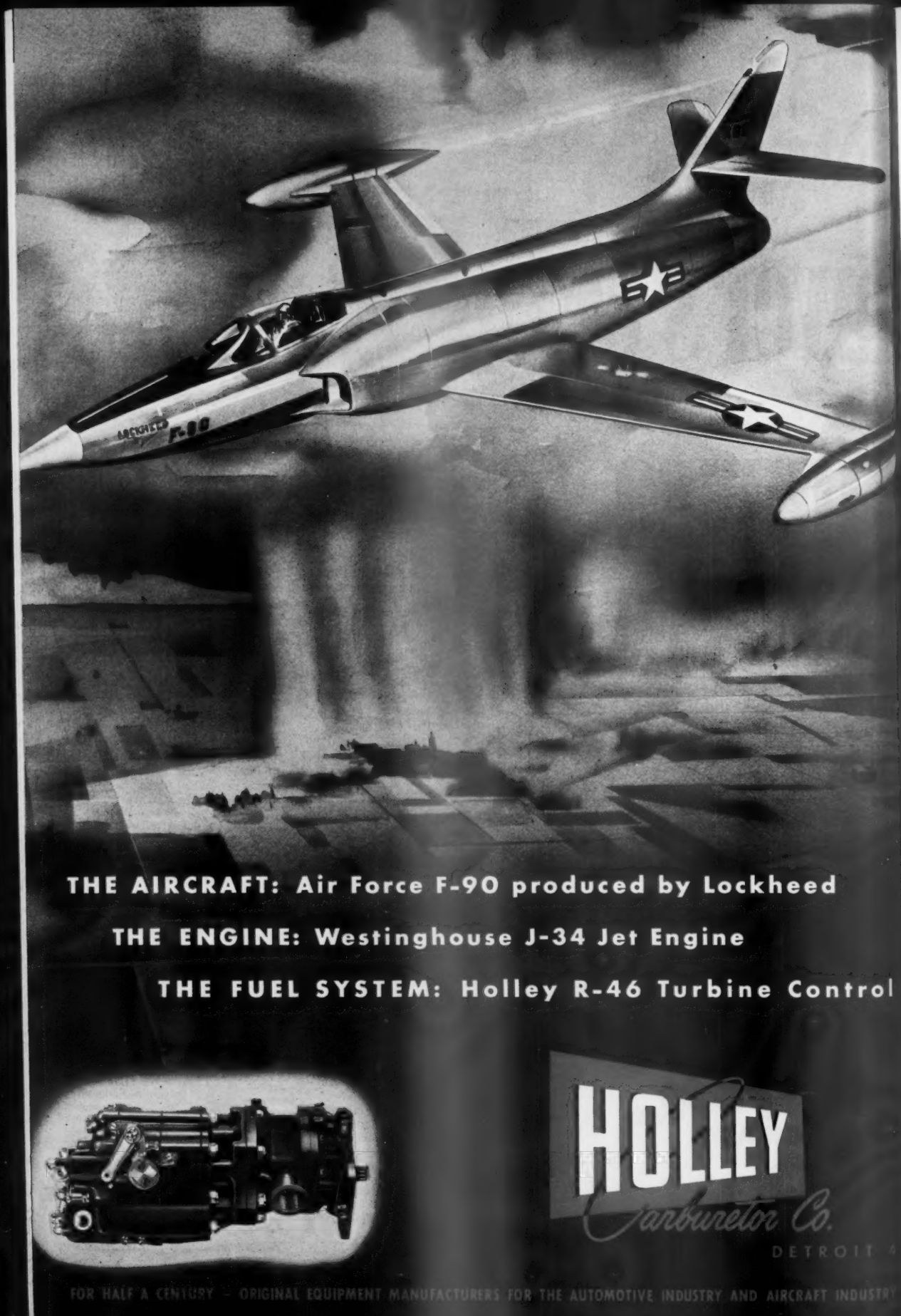

THE AIRCRAFT: Air Force F-90 produced by Lockheed

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THE FUEL SYSTEM: Holley R-46 Turbine Control

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Aeronautical Reviews

A Guide to the Current Literature of Aeronautical Research and Engineering

I. PERIODICALS AND REPORTS

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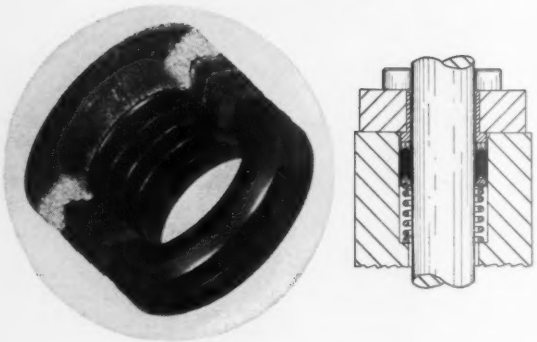

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Aerodynamics (2)

Ernst Mach—Pioneer of Supersonics. Joseph Black. *Royal Aeronautical Society, Journal*, Vol. 54, No. 474, June, 1950, pp. 371–377, illus. 7 references.

BOUNDARY LAYER

Shear Stress in a Turbulent Boundary Layer. Donald Ross and J. M. Robertson. *Journal of Applied Physics*, Vol. 21, No. 6, June, 1950, pp. 557–561, illus.

A theory for the shear stress distribution in a turbulent boundary layer which has been developed upon the space-history of the turbulence and was evolved from Jacob's observations that the shear stress gradient in the outer portion of the boundary layer is constant even when the external flow conditions vary in the direction of flow. As in Fediaevsky's method, boundary values are used to determine an arbitrary polynomial. The theory yields a linear shear profile at the beginning of the adverse pressure gradient; and, as the boundary layer progresses, this linear characteristic is relegated to the outer part and the shear in the inner region is determined by local conditions. Comparison with shear measurements made at the National Bureau of Standards shows good agreement and appreciable improvement over Fediaevsky's theory.

Wave Reflection near a Wall. A. Robinson. *College of Aeronautics, Cranfield, England, Report No. 37*, May, 1950. 25 pp., illus. 7 references.

An analysis of an arbitrary continuous velocity profile that varies from zero at a wall to a constant supersonic velocity in the main stream. The calculated numerical examples indicate that a simple inviscid theory is incapable of giving an adequate theoretical account of the modifications of the field of flow caused by a shock wave or expansion wave in the neighborhood of a rigid wall. The analysis includes a detailed discussion of the process of continuous wave reflection in a supersonic shear layer.

Interferometric Studies on Laminar and Turbulent Boundary Layers Along a Plane Surface at Supersonic Velocities. R. Ladenburg and D. Bershader. (Symposium on Experimental Compressible Flow, June 29, 1950.) *U.S. Naval Ordnance Laboratory, Report No. 1133*, May 1, 1950, pp. 67–86, illus. 8 references.

Shadowgrams and schlieren pictures made in an intermittent wind tunnel with a free stream not completely void of turbulence show clearly that the compressible boundary layer along a plane surface at $M = 2.3$ is turbulent when the Reynolds Number is greater than 2×10^6. When the Reynolds Number is less than 6×10^5, the velocity profile is different and not far from the theoretical profile expected for laminar boundary layers at high velocities. There is no sudden, but a gradual, transition to fully turbulent character when the Reynolds Number is increased above 6×10^5.

Boundary-Layer Shock-Wave Interaction. H. W. Liepmann. (Symposium on Experimental Compressible Flow, June 29, 1950.) *U.S. Naval Ordnance Laboratory, Report No. 1133*, May 1, 1950, pp. 39–64, illus. 13 references.

Examination of shock-wave reflection from a boundary layer on a flat surface in uniform supersonic flow shows the characteristic difference between laminar and turbulent boundary phenomena to be the same as in the transonic case. The shock-wave expansion-zone reflection pattern is apparent. The pressure distribution ahead of the shock wave in the laminar case and the turbulent case are typical over a fairly wide range of Mach Number and shock strengths, and the influence of the laminar boundary layer upon the reflection pattern of a shock wave is extensive. The determining difference between laminar and turbulent boundary layers is not the subsonic boundary-layer thickness but is rather both the shape of the velocity profile and its development in a pressure gradient.

A Determination of the Laminar-, Transitional-, and Turbulent-Boundary-Layer Temperature-Recovery Factors on a Flat Plate in Supersonic Flow. Jackson R. Stalder, Morris W. Rubesin, and Thorval Tendeland. *U.S., N.A.C.A., Technical Note No. 2077*, June, 1950. 20 pp., illus. 12 references.

A Theoretical Investigation of Heat Transfer in the Laminar Flow Regions of Airfoils. Leonard Goland. *Journal of the Aeronautical Sciences*, Vol. 17, No. 7, July, 1950, pp. 436–440, illus. 9 references.

Investigations of the Wall-Shearing Stress in Turbulent Boundary Layers. H. Ludwieg and W. Tillmann. *U.S.*,

N.A.C.A., Technical Memorandum No. 1285, May, 1950. 25 pp., illus. 17 references.

Readers' Forum: On the Stability of the Boundary Layer over a Cone. R. H. Battin and C. C. Lin. *Journal of the Aeronautical Sciences,* Vol. 17, No. 7, July, 1950, pp. 453, 454. 2 references.

General Solution of Prandtl's Boundary-Layer Equation. W. Mangler. (*Lilienthal-Gesellschaft für Luftfahrtforschung, Bericht Nr. 141,* October, 1941.) *U.S., N.A.C.A., Technical Memorandum No. 1278,* June, 1950. 20 pp., illus. 12 references.

Interferometer Corrections and Measurements of Laminar Boundary Layers in Supersonic Stream. Robert E. Blue. *U.S., N.A.C.A., Technical Note No. 2110,* June, 1950. 74 pp., illus. 8 references.

FLUID MECHANICS & AERODYNAMIC THEORY

Transient Source, Doublet and Vortex Solutions of the Linearized Equations of Supersonic Flow. W. J. Strang. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences,* Vol. 202, No. 1068, June 22, 1950, pp. 40–53, illus. 5 references.

By introducing the Heaviside step function as the time variation of the fundamental source solution of the wave equation of compressible gas flow, a family of "transient" source and doublet solutions, together with a generalization of the vortex, are derived which are applicable to unsteady supersonic airfoil theory.

The Formation and Growth of Shock Waves in the One-Dimensional Motion of a Gas. A. F. Pillow. *Cambridge Philosophical Society, Proceedings,* Vol. 45, Part 4, 1949, pp. 558–586, illus. 4 references. (Reprint.)

By neglecting reflections and entropy variations behind the shock, in the case of a constantly accelerated piston, a first approximation is found for the one-dimensional motion of a homogeneous gas in an infinite tube that is closed at one end. Using this as a basis, a second approximation is found for the entropy in the neighborhood of the initial portion of the shock line. The problem then reduces to the solution of a second-order linear partial differential equation. By introducing a Riemann function and satisfying the boundary conditions at the shock, an integral equation is obtained which enables the position of the shock as a function of time to be determined. The solution is a power series that is valid if the shock wave does not become too strong. If the piston is given a constant terminal velocity, a reflected wave from the shock is reflected again from the piston and eventually overtakes the shock and reduces its velocity to a final steady value that is in agreement with the value arising from an impulsive start.

Methods for Investigation of Flows at Transonic Speeds. John Stack. (Symposium on Experimental Compressible Flow, June 29, 1950.) *U.S. Naval Ordnance Laboratory, Report No. 1133,* May 1, 1950, pp. 1–37, illus. 7 references. A summary of free-fall, rocket, wing-flow, and wind-tunnel techniques.

Letters to the Editor: On Turbulent Jet Mixing in Two-Dimensional Supersonic Flow. D. Bershader and S. I. Pai. *Journal of Applied Physics,* Vol. 21, No. 6, June, 1950, p. 616, illus. 5 references.

Note on Free Turbulent Flows, with Special Reference to the Two-Dimensional Wake. G. K. Batchelor. *Journal of the Aeronautical Sciences,* Vol. 17, No. 7, July, 1950, pp. 441–445, illus. 9 references.

Hypothesis for Skewness of the Probability Density of the Lateral Velocity Fluctuations in Turbulent Shear Flow. Stanley Corrsin. *Journal of the Aeronautical Sciences,* Vol. 17, No. 7, July, 1950, pp. 396–398, illus. 6 references.

A Mechanical Analogy for Hypersonic Flow. H. Reese Ivey. *Journal of the Aeronautical Sciences,* Vol. 17, No. 8, August, 1950, pp. 519–524, illus. 1 reference.

Theoretical Wave Drags and Pressure Distributions for Axially Symmetric Open-Nose Bodies. John R. Jack. *U.S., N.A.C.A., Technical Note No. 2115,* June, 1950. 35 pp., illus. 5 references.

Prandtl-Meyer Flow for a Diatomic Gas of Variable Specific Heat. Robert N. Noyes. *U.S., N.A.C.A., Technical Note No. 2125,* June, 1950. 22 pp., illus. 3 references.

Linearized Supersonic Axially Symmetric Flow About Open-Nosed Bodies Obtained by Use of Stream Function. Franklin Moore. *U.S., N.A.C.A., Technical Note No. 2116,* June, 1950. 30 pp., illus. 8 references.

Readers' Forum: Base Pressures at Supersonic Velocities. A. Gabeaud. *Journal of the Aeronautical Sciences,* Vol. 17, No. 8, August, 1950, pp. 525, 526. 1 reference.

Readers' Forum: On the Stability for a Certain Degenerate Type of Disturbance of Viscous Fluid Flow Between Parallel Walls. S. I. Pai. *Journal of the Aeronautical Sciences,* Vol. 17, No. 8, August, 1950, p. 525.

INTERNAL FLOW

Two-Dimensional Compressible Flow in Turbomachines with Conic Flow Surfaces. John D. Stanitz. *U.S., N.A.C.A., Report No. 935,* 1949. 25 pp., illus. 10 references. U.S. Govt. Printing Office, Washington. $0.25.

The Influence of Design Parameters on the Performance of Subsonic Air Inlets. Howard E. Roberts and B. D. Langtry. *Journal of the Aeronautical Sciences,* Vol. 17, No. 7, July, 1950, pp. 429–435, 455, illus. 4 references.

The Development and Application of High-Critical-Speed Nose Inlets. Donald D. Baals, Norman F. Smith, and John B. Wright. *U.S., N.A.C.A., Report No. 920,* 1948. 58 pp., illus. 13 references. U.S. Govt. Printing Office, Washington. $0.35.

Design and Performance of Family of Diffusing Scrolls with Mixed-Flow Impeller and Vaneless Diffuser. W. Byron Brown and Guy R. Bradshaw. *U.S., N.A.C.A., Report No. 936,* 1950. 10 pp., illus. 3 references. U.S. Govt. Printing Office, Washington. $0.15.

A New Method of Designing Two-Dimensional Laval Nozzles for a Parallel and Uniform Jet. Kuno Foelsch. *North American Aviation, Inc., Engineering Department, Thermodynamics Section, Report No. NA-46-235-2,* May 27, 1946. 48 pp., illus. 4 references.

An analytical determination of the contours of a two-dimensional nozzle for effecting ideal expansion of gases to a uniform parallel jet which eliminates the laborious graphical construction and the graphical error inherent in the Prandtl-Buseman method. The mathematical equations that are developed permit the immediate determination of the coordinates of any streamline in point-source flow. The equations are extended to permit solution of the flow from the parallel throat section of a laval nozzle.

Three Dimensional Nozzle Study for the University of Washington Supersonic Wind Tunnel. D. W. Lueck and Alexander J. Wang. *Washington, University, Aeronautical Laboratory, Engineering Experiment Station, Research Project No. 34, Report No. 303,* June 8, 1949. 22 pp., illus. $1.25.

Sauer's semigraphical integration methods were used to compute the three-dimensional nozzle ordinates for axially symmetric nozzle blocks of the University of Washington 3- × 3-in. supersonic wind tunnel. One nozzle was designed for Mach 3.15 and another for Mach 5.49. Comparison of these methods with those of Cronvich and those of Foelsch showed Sauer's method, although tedious, to be the best practical approach to the theoretical flow conditions.

Performance of Conical Jet Nozzles in Terms of Flow and Velocity Coefficients. Ralph E. Gray and H. Dean Wilsted. *U.S., N.A.C.A., Report No. 933.* 9 pp., illus. 1 reference. U.S. Govt. Printing Office, Washington. $0.15.

Linearized Supersonic Axially Symmetric Flow About Open-Nosed Bodies Obtained by Use of Stream Function. Franklin Moore. *U.S., N.A.C.A., Technical Note No. 2116,* June, 1950. 30 pp., illus. 8 references.

Theoretical Wave Drags and Pressure Distributions for Axially Symmetric Open-Nose Bodies. John R. Jack. *U.S., N.A.C.A., Technical Note No. 2115,* June, 1950. 35 pp., illus. 5 references.

PARASITIC COMPONENTS & INTERFERENCE

Readers' Forum: Note on "Interference Between Wing and Body at Supersonic Speeds." Ray E. Bolz. *Journal of the Aeronautical Sciences,* Vol. 17, No. 7, July, 1950, p. 453.

PERFORMANCE

Readers' Forum: The Effects of Weight Variation on the Range of Air-Borne Craft. Ralph W. Allen. *Journal of the Aeronautical Sciences,* Vol. 17, No. 8, August, 1950, pp. 527, 528, illus.

STABILITY & CONTROL

Maximum Pitching Angular Accelerations of Airplanes Measured in Flight. Cloyce E. Matheny. *U.S., N.A.C.A., Technical Note No. 2103,* May, 1950. 19 pp., illus. 9 references.

Flight test data and analysis compiled from manufacturers' reports, N.A.C.A. papers, and unpublished tests by Langley Aeronautical Laboratory. The compilation is for conventional airplanes, and data are for Mach Numbers below 0.80.

A New Approach to the Analysis of Airplane Motions. E. V. Laitone. *Paper presented at the International Congress of Applied Mechanics, 6th, Paris,* September, 1946. 5 pp. 3 references.

By considering the velocity rather than the displacement of an airplane as a fundamental variable and by considering the rate of control-surface motion as well as its displacement as the forcing function producing the moment applied to the airplane, the equations of motion for small deviations of an airplane from its level flight path are transformed to a form similar to that for a simple spring-mass-damping mechanical system. The equivalent spring and damping constants are functions of the conventional stability derivatives and depend only upon the airplane geometry, air density, and flight speed. They may be evaluated in flight by means of a continuous sinusoidal control surface motion. A comparison of the spring and damping constants for different airplanes provides a simple evaluation of the relative dynamic stability of each airplane. A graphical method can be used to determine rapidly the airplane motion that will result from a given control-surface deflection or the control-surface deflection required for a desired airplane motion.

Application of Frequency-Response Analysis to Aircraft-Autopilot Stability. Charles L. Seacord, Jr. *Journal of the Aeronautical Sciences,* Vol. 17, No. 8, August, 1950, pp. 481–498, illus. 87 references.

Longitudinal Stability of Autopilot-Controlled Aircraft. Andrew Vazsonyi. *Journal of the Aeronautical Sciences,* Vol. 17, No. 7, July, 1950, pp. 399–416, illus. 5 references.

WINGS & AIRFOILS

Transient Lift of Three-Dimensional Purely Supersonic Wings. W. J. Strang. *Royal Society of London, Proceedings, Series A, Mathematical and Physical Sciences,* Vol. 202, No. 1068, June 22, 1950, pp. 54–80, illus. 12 references.

A theory given by Strang for the transient lift of two-dimensional supersonic wings is extended to cover purely supersonic three-dimensional wings. A simple function of two variables can be defined to express all the pressure distributions. Charts are given for calculating the unsteady lift of wings with plan forms made up of a finite number of straight lines. For delta wings, the important parameters are the Mach Number and chord-distance traveled. The sweepback is less significant. Plan forms of small aspect ratio are the most advantageous from the point of view of gust loading because of their greater chord length for given area.

A Comparison of the Calculated Profile Drag Coefficients of Various Low Drag Wing Sections. E. M. Dowlen. *College of Aeronautics, Cranfield, England, Report No. 35,* April, 1950. 10 pp., illus. 11 references.

Low-drag wings with straight trailing edges, other low-drag wings, and conventional sections. For a given transition point position, the profile drag increases with rearward movement of the position of maximum velocity and with increase of trailing-edge angle.

Two Electrical Analogies for the Pressure Distribution on a Lifting Surface. W. F. Campbell. *Canada, National Research Council, Division of Mechanical Engineering, Aerodynamics Laboratory, Report No. MA-219,* October 18, 1949. 44 pp., illus. 24 references.

By suitable control of the boundary conditions, the electrical potential in a deep electrolytic tank may be made to correspond to the perturbation velocity potential or the acceleration potential of the steady flow of an incompressible fluid over a thin lifting airfoil of arbitrary plan form with small camber, twist, and angle of attack. Either the direct or the inverse problems may be handled

Aerodynamic Shape of the Wing Tips. Sighard Hoerner. *U.S., Air Force, Technical Report No. 5752 (ATI No. 52752),* 1950. 5 pp., illus. 9 references.

German investigations show that wing tips can be designed to reduce the wing-tip vortex. By thus reducing the parasitic drag, the rate of climb of an aircraft can be increased by 1 ft. per sec. and the range by 1 to 2 per cent.

Comparison Between Theory and Experiment for Wings at Supersonic Speeds. Walter G. Vincenti. *U.S., N.A.C.A., Technical Note No. 2100,* June, 1950. 29 pp., illus. 15 references.

Theoretical Calculations of the Lateral Force and Yawing Moment Due to Rolling at Supersonic Speeds for Sweptback Tapered Wings with Streamwise Tips; Subsonic Leading Edges. Kenneth Margolis. *U.S., N.A.C.A., Technical Note No. 2122,* June, 1950. 33 pp., illus. 16 references.

Formulas and Charts for the Supersonic Lift and Drag of Flat Swept-Back Wings with Interacting Leading and Trailing Edges. Doris Cohen. *U.S., N.A.C.A., Technical Note No. 2093,* May, 1950. 36 pp., illus. 14 references.

Development of a Wing Flow Apparatus for Transonic Aerodynamic Tests. *Canada, National Research Council, Division of Mechanical Engineering, Flight Research Section, Report No. MR-6,* August 26, 1949, 8 pp., illus. 1 reference. Construction, instrumentation, balances, and calibration.

Air Transportation (41)

The Economics of Turbine Transport. J. R. Kitto and A. W. Millson. *Shell Aviation News,* No. 142, April, 1950, pp. 18–20, illus.

An analysis of the operating economics of the Vickers Viscount and a comparison of the propeller-jet, piston, and pure-jet power plants. Curves show direct operating costs and annual return on capital expenditure.

Do We Need Turboprops? E. V. Farrar and R. E. Johnson. *Aeronautical Engineering Review,* Vol. 9, No. 7, July, 1950, pp. 30–34, illus.

Air Transportation Finds New and Lucrative Uses for SQC (Statistical Quality Control). Dale L. Lobsinger. *Industrial Quality Control,* Vol. 6, No. 6, May, 1950, pp. 76–78, illus. Food service, pay-load control, reservations, and cabin service irregularities.

Prop Turbines to Extend Useful Life of Dakota (Douglas DC-3). *Canadian Aviation,* Vol. 23, No. 6, June, 1950, pp. 20, 21, 48, 50, illus.

Jet-Transport Conference (I.A.T.A.). *Flight,* Vol. 57, No. 2164, June 15, 1950, pp. 709–715, illus. Questions and answers as given at the Conference.

United States Overseas Air Cargo Services. III. N. W. Kendall. *Air Transportation,* Vol. 16, No. 6, June, 1950, pp. 11, 16, 17, 25, illus.

Palletisation of Freight for Transport; Contribution to Higher Productivity; Extensively Used at Vauxhall Works. II. *Modern Transport,* Vol. 63, No. 1628, June 10, 1950, p. 8, illus.

The Backhaul Problem; Lower Minimums May Be the Answer to Directional Unbalance. John H. Frederick. *Distribution Age,* Vol. 49, No. 6, June, 1950, pp. 24, 32, 33, illus.

Off-Peak Air Services; European Developments Reviewed. *Modern Transport,* Vol. 63, No. 1629, June 17, 1950, pp. 7, 17 illus.

A New Empire Route; Possibilities of Utilizing Islands in the Indian Ocean: Value in Peace and War. Derek Dudley Martin *Flight,* Vol. 57, No. 2161, May 25, 1950, pp. 637–639, illus.

Airplane Design & Description (10)

Maintenance Consideration in Development of New Aircraft. William H. Wheeler. *Air University Quarterly Review,* Vol. 3, No. 4, Spring, 1950, pp. 39–45.

In order to achieve operational efficiency as well as desired performance, the military characteristics of a proposed aircraft should be supplemented with specific requirements under structure and design to facilitate maintenance and servicing. Greater maintenance representation and authority should be given at Mock-Up and Engineering Acceptance Inspections which should be held on the first X-model airplane rather than on the production article. Specifications on the installation of systems should stress greater accessibility for inspection and servicing.

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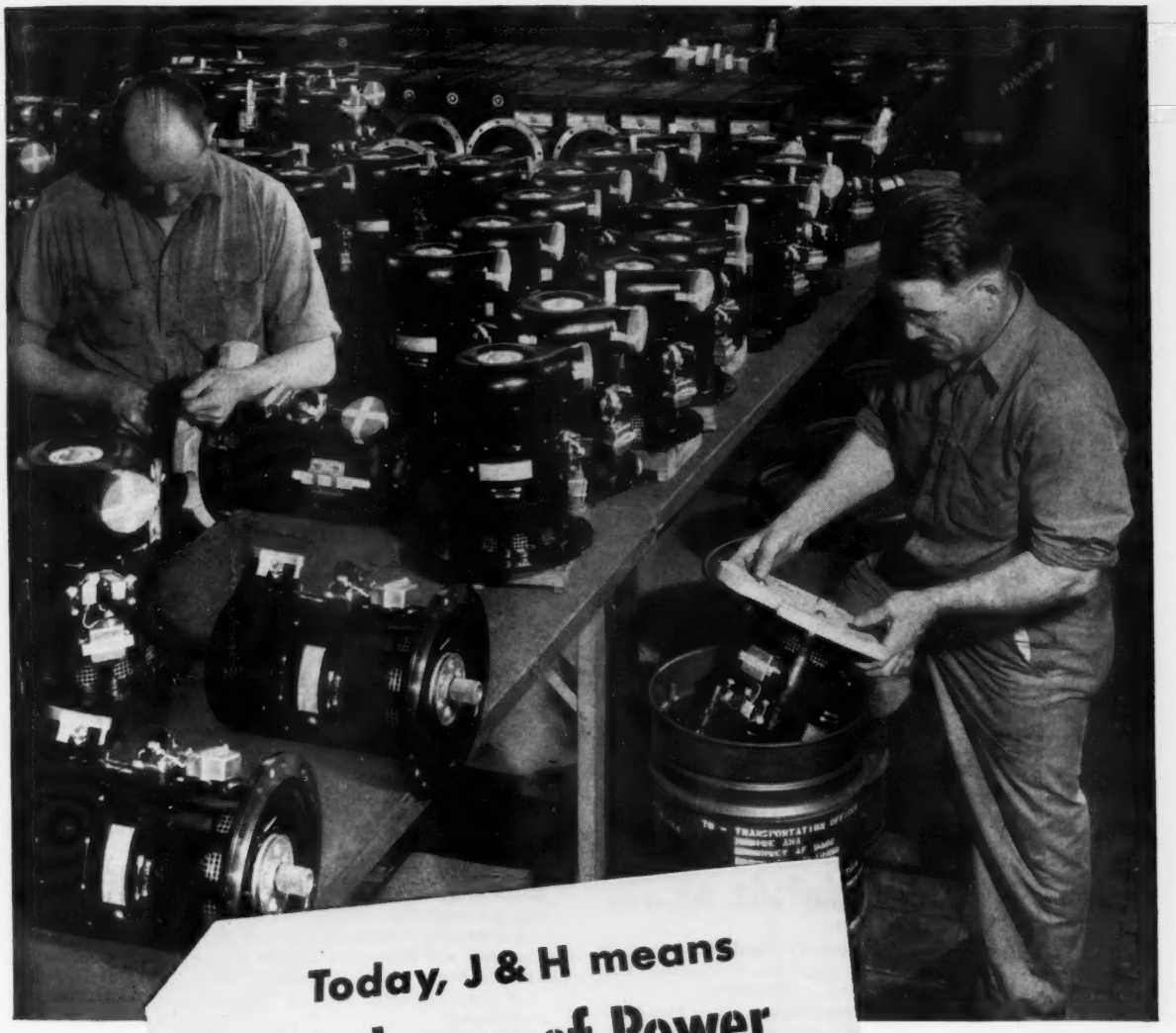

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Lucas flow control of the Mamba; Lucas accumulator, trip valve, and high-pressure cock of the Derwent; pressurizing valve, shut-off cock, and dump of the Nene; and "Simplex," "Duplex I," and Armstrong-Siddeley burners.

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An Investigation into Engine Wear Caused by Dust. R. V. Pavia. *Australia, Department of Supply and Development, Aeronautical Research Laboratories, Report No. E. 65*, January, 1950. 44 pp., illus. 7 references.

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ROCKET (4)

Application of Near-Equilibrium Criteria During Adiabatic Flow to Representative Propellant Systems. S. S. Penner. *Franklin Institute, Journal*, Vol. 249, No. 6, June, 1950, pp. 441–448, illus. 7 references.

An analysis of criteria for establishing near equilibrium or wide departures from thermodynamic equilibrium during adiabatic flow through a nozzle. The adiabatic expansion of the combustion products produced in the hydrogen-fluorine motor using the reactants in stoichiometric proportions should occur under conditions closely approximating thermodynamic equilibrium. The decomposition of nitric oxide demonstrates the departure from thermodynamic equilibrium. The equilibrium involving nitric oxide, nitrogen, and oxygen suggests that practically frozen flow occurs below certain temperatures. Uncertainties in the rate of constants for the chemical reactions under consideration do not justify a more detailed study of the extent of chemical reaction during flow than is afforded by application of these simple criteria.

Rocket Motor Hydraulics. George P. Sutton. *Machine Design*, Vol. 22, No. 5, May, 1950, pp. 86–91, illus. 2 references.

Basic components and hydraulic characteristics of the pump-feed and the gas-feed hydraulic systems used to control the flow of propellants in liquid-propellant rocket power plants.

Reaction Motors' Liquid-Propellant Rockets. *American Aviation*, Vol. 14, No. 3, July 1, 1950. pp. 17, 19–21. illus.

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Production (36)

The Air Force Approach to Statistical Quality Control. O. C. Griffith. *Industrial Quality Control*, Vol. 6, No. 6, May, 1950, pp. 26–28.

New Saw Speeds (Boeing) B-47 Skin Fitting. *Aviation Week*, Vol. 52, No. 24, June 12, 1950, p. 18, illus.

Contour-Sawing Setups. H. J. Chamberland. *Aero Digest*, Vol. 60, No. 5, May, 1950, pp. 40, 41, 107, illus.

Martin's Low Cost Lofting Practices. H. C. Ricker. *The Martin Star*, Vol. 9, No. 6, June, 1950, pp. 14, 15, illus.

Cold Extrusion of Steel. J. Parker Bowden. *Steel Processing*, Vol. 36, No. 5, May, 1950, pp. 227–232, illus.

Forming Sheetmetal by the Marform Process. R. B. Schulze. *The Tool Engineer*, Vol. 24, No. 5, May, 1950, pp. 41–43, illus.

The "Lost Wax" Process of Precision Casting. J. S. Turnbull. *Institution of Mechanical Engineers, Proceedings*, Vol. 162, No. 1, 1950, pp. 66–74, illus.

Stretch-Forming; New-Type Machine Developed and Installed at Fairey Aviation Co., Ltd.: Over-Blade and Under-Blade Methods of Working. *Aircraft Production*, Vol. 12, No. 140, June, 1950, pp. 184–189, illus. Press is particularly suited for forming of long, narrow profiles such as high-speed airfoil leading edges.

Contour and Profile Investigation. II—Work-Holding Devices: Comparator Equipment and Special-Purpose Optical Apparatus for Dual Projection. *Aircraft Production*, Vol. 12, No. 140, June, 1950, pp. 192–197, illus. Techniques and equipment developed at D. Napier & Son, Ltd., for inspection of gas-turbine blades and similar work.

Stores Organization. IV—Handling Materials and Supplies for Airframe-Assembly Operations; Packing and Despatch. Richard Twelvetrees. *Aircraft Production*, Vol. 12, No. 140, June, 1950, pp. 202–205, illus. Procedure at the Richmond Road Factory of Hawker Aircraft, Ltd.

Coin-Dimpling; Counter-Pressure Process for the Accurate Control of Rivet-Head Form. I—Basic Principle and Governing Factors. *Aircraft Production*, Vol. 12, No. 140, June, 1950, pp. 181–183, illus. Process originated at North American Aviation, Inc.

Soft Grits Provide Low Cost Method for Blast Cleaning Metals. T. F. Clark and E. C. Lathrop. *Materials & Methods*, Vol. 31, No. 5, May, 1950, pp. 67–69, illus. 2 references.

Metlbonding Saves Time, Money on B-36; New Convair Adhesive Development Speeds Production of 5500 Sq. Ft. of Superbomber's Skin Assemblies. *Aviation Week*, Vol. 52, No. 25, June 19, 1950, pp. 20, 22, 25, 26, illus.

Use of Pressurized Gases in the Aircraft Industry. Floyd H. Matthews. *International Acetylene Association*, March, 1950. 9 pp.

Propellers (11)

Boost Pressure Feathering Safety Switch. C. H. Peek. *The Technical Instructor*, Vol. 5, No. 5, May, 1950, pp. 14, 15, illus.

A safety device (applicable to all supercharged engines) to ensure that in the event of an engine failure (on twin- or multi-engined aircraft) during take-off, the pilot does not inadvertently feather the good engine.

Research Facilities (50)

The Role of Research. L. B. Richardson. *The Pegasus*, Vol. 15, No. 6, June, 1950, pp. 5–7, illus.

Aeronautical Research in Britain; The Work of the Aerodynamics Division, National Physical Laboratory. V. S. Swaminathan. *Interavia*, Vol. 5, No. 4, 1950, pp. 204–207, illus.

Space Travel

The Ideal Impulse. Hermann Oberth. (*Wege zur Raumschiffahrt*, Munich, 1925, Part 2, Chapter 6, pp. 36–44.) *Rocket-science*, Vol. 4, No. 2, June, 1950, pp. 26–30, illus. 4 references.

Structures (7)

On the Theory of Flutter and an Iterative Method of Calculating the Critical Speed of a Wing. Pentti Laasonen. *Sweden, Kungl. Tekniska Högskola, Institution för Flygteknik, Technical Note No. KTH-AERO TN 11*, April 20, 1950. 12 pp., illus.

Since at the limit of dynamic stability a mechanical system has as its oscillating frequency a purely imaginary eigenvalue that is equivalent to a harmonic motion, in order to determine the critical speed of a wing it is only necessary to investigate harmonic oscillations the amplitude functions of which satisfy an eigenvalue differential system of the sixth order. Since the coefficients of these equations are complex solutions, sufficient accuracy cannot be obtained by methods that employ assumed solutions in which the amplitude functions are real. Therefore, the Engesser-Vainello iterative method has been generalized for the solution of groups of differential equations.

Free Vibration Characteristics of Rectangular Cantilever Plates. M. V. Barton. *Texas, University, Defense Research Laboratory, Report No. CF-1258 DRL-212*, May 24, 1949. 14 pp., illus. 6 references.

An investigation of the frequencies and modes of free vibration of missile fins idealized as flat rectangular plates, fixed along one edge, and with cantilever span to chord ratios of $^1/_2$, 1, 2, and 5. Equations are set up in terms of influence coefficients and solved by matrix integration, and the Ritz energy method is also used. The first plate bending (symmetric) frequency corresponds closely to that of a uniform cantilever beam modified to account for the plate flexural rigidity factor. The first torsional (antisymmetric) frequency varies almost linearly with plate length-to-breadth ratio. An empirical equation facilitates the determination of this frequency. Experimental spot checks on a square cantilever plate indicate agreement within 2 per cent of theoretical values for the first two frequencies.

Buckling Stress of Box-Beams Under Pure Bending. Sigge F. Eggwertz. *Sweden, Flygtekniska Försöksanstalt, Meddelande Nr. 33*, 1950. 57 pp., illus. 36 references.

A simple method for calculating the buckling stresses of plates with elastic restraint along the edges, which was developed from the method of moment distribution for rigid frames, was extended to built-up sections with an arbitrary number of cells where the influence of the torsional stiffness of the attachments between the webs and the cover skin is taken into account. The theoretical values obtained for one-cell and three-cell beams were verified by test results. The necessary formulas are given for beams with four and an infinite number of cells. Diagrams based on a number of computations of buckling coefficients show the influence of different geometric ratios of box sections and the influence of the number of cells.

The Solution of Aeroelastic Problems by Electronic Analogue Computation. Jonathan Winson. *Journal of the Aeronautical Sciences*, Vol. 17, No. 7, July, 1950, pp. 385–395, illus. 11 references.

Study of Effects of Sweep on the Flutter of Cantilever Wings. J. G. Barmby, H. J. Cunningham, and I. E. Garrick. *U.S., N.A.C.A., Technical Note No. 2121*, June, 1950. 74 pp., illus. 9 references.

Readers' Forum: Note on the Calculation of Deflections of Indeterminate Structures. Bruno A. Boley and Roland H. Moore. *Journal of the Aeronautical Sciences*, Vol. 17, No. 8, August, 1950, pp. 526, 527, illus.

Readers' Forum: Complementary Energy Method in Vibration Analysis. A. I. van de Vooren and J. H. Greidanus. *Journal of the Aeronautical Sciences*, Vol. 17, No. 7, July, 1950, pp. 454, 455, illus. 2 references.

Readers' Forum: Determination of Flutter Frequencies and Speeds. E. Reissner. *Journal of the Aeronautical Sciences*, Vol. 17, No. 7, July, 1950, p. 455. 2 references.

Visualization of Fundamental Principles in Elasticity Using Rubber Models. A. J. Durelli, C. H. Taso, and R. H. Jacobson. *Journal of Engineering Education*, Vol. 40, No. 9, May, 1950, pp. 525–531, illus.

Tables of Characteristic Functions Representing Normal Modes of Vibration of a Beam. Dana Young and Robert P. Felgar, Jr. *Texas, University, Engineering Research Series No. 44*, July 1, 1949. 31 pp., illus. 10 references.

Tabulated values of the characteristic function and its first three derivatives for each of the first five modes of the clamped-clamped beam, the clamped-free beam, and the clamped-supported beam. The functions are tabulated to five decimal places at intervals of the argument corresponding to $^1/_{50}$ of the beam length.

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Column Buckling in the Elastoplastic Range. P. Cicala. *Journal of the Aeronautical Sciences*, Vol. 17, No. 8, August, 1950, pp. 508–512, illus. 3 references.

Torsion of Thin-Walled Closed Cylinders Beyond the Elastic Limit. G. H. Handelman. *Journal of the Aeronautical Sciences*, Vol. 17, No. 8, August, 1950, pp. 499–507, 518, illus. 8 references.

Two Dimensional Theory of Stiffened Plates. Chang O'Chou. *The Aeronautical Quarterly*, Vol. 2, Part 1, May, 1950, pp. 1–8, illus.

The general stress distribution of a stiffened plate can be obtained by considering both the ribs and the stringers of a stiffened plate to be uniformly distributed. The complete solution of the fundamental differential equation of the two-dimensional stiffened plate problem renders all solutions for the isotropic plate also available for the stiffened plate.

Bifurcation Criterion and Plastic Buckling of Plates and Columns. C. E. Pearson. *Journal of the Aeronautical Sciences*, Vol. 17, No. 7, July, 1950, pp. 417–424, 452, illus. 9 references.

Experimental Values of Natural Frequencies for Skew and Rectangular Cantilever Plates. J. W. Dalley and E. A. Ripperger. *Texas, University, Defense Research Laboratory, Report No. CF-1354 DRL-231*, December 16, 1949. 17 pp., illus.

An investigation of the dynamic characteristics of thin, skewed cantilever plates, with low length-to-breadth ratios, representing idealized missile fins. Natural frequencies and pictures of the node patterns were obtained for the first five modes of vibration for cantilever plates with 0°, 15°, 30°, 45°, and 60° angles of skew. Curves were plotted to show the variation in natural frequency with skew angle. Experimental values of the natural frequencies for the first three modes are also given for rectangular plates with length-to-breadth ratios of $^1/_2$, 1, 2, and 5.

Structural Fatigue. H. A. Wills. *Aircraft*, Vol. 28, No. 8, May, 1950, pp. 12–14, 46, 48, illus.

A survey of the program of the Australian Commonwealth Aeronautical Laboratories to establish statistically the fluctuating load conditions to which an aircraft will be subjected in operation and of experimental investigations to determine the fatigue strengths of aircraft wing structures under a comprehensive range of fluctuating load conditions.

Thermodynamics (18)

General Method for Computation of Equilibrium Composition and Temperature of Chemical Reactions. Vearl N. Huff and Virginia E. Morrell. *U.S., N.A.C.A., Technical Note No. 2113*, June, 1950, 47 pp., illus. 6 references.

Application of the Membrane Analogy to the Solution of Heat-Conduction Problems. L. H. Wilson and A. J. Miles. *Journal of Applied Physics*, Vol. 21, No. 6, June, 1950, pp. 532–535, illus. 14 references.

Water-Borne Aircraft (21)

Development of High-Speed Water-Based Aircraft. Ernest G. Stout. *Journal of the Aeronautical Sciences*, Vol. 17, No. 8, August, 1950, pp. 457–480, illus. 10 references.

Hydrodynamic Longitudinal Stability. George S. Schairer. *Journal of the Aeronautical Sciences*, Vol. 17, No. 8, August, 1950, pp. 513–518, illus.

Wind Tunnels (17)

A Design Study of Low Density Supersonic Wind Tunnels. Girvis E. Ledbetter. *Washington, University, Aeronautical Laboratory Report No. 302*, May, 1949. 145 pp., illus. 55 references. $5.15.

A generalized aerodynamic study of the parts of supersonic wind tunnels with particular reference to those tunnels that operate at standard atmospheric stagnation conditions at Mach Numbers from 1 to 7. The study was used as background for the design of a 3- × 3-in. tank-driven intermittent wind tunnel with interchangeable two-dimensional nozzle blocks for Mach Numbers of 3 and 5.35, and for a 1- × 2-in., two-dimensional, $M = 3$, closed circuit continuously-operating arrangement with an oil-seal rotary vacuum pump drive. Although the operating densities and pressures are well below standard atmospheric values at all points between the first contraction and the vacuum pump, the data in the study are either directly applicable to, or can be extended for, stagnation pressures to several atmospheres.

The Design of Low-Turbulence Wind Tunnels. Hugh L. Dryden and Ira H. Abbott. *U.S., N.A.C.A., Report No. 940*, 1949. 12 pp., illus. 34 references. U.S. Govt. Printing Office, Washington. $0.15.

An outline of design principles. The $4^1/_2$-foot wind tunnel of the National Bureau of Standards and the N.A.C.A. Langley two-dimensional low-turbulence pressure tunnel are used as examples.

Three Dimensional Nozzle Study for the University of Washington Supersonic Wind Tunnel. D. W. Lueck and Alexander J. Wang. *Washington, University, Aeronautical Laboratory, Engineering Experiment Station, Research Project No. 34, Report No. 303*, June 8, 1949. 22 pp., illus. $1.25.

Sauer's semigraphical integration methods were used to compute the three-dimensional nozzle ordinates for axially symmetric nozzle blocks of the University of Washington 3- × 3-in. supersonic wind tunnel. One nozzle was designed for Mach 3.15 and another for Mach 5.49. Comparison of these methods with those of Cronvich and those of Foelsch showed Sauer's method, although tedious, to be the best practical approach to the theoretical flow conditions.

A Few Aspects of Future Supersonic Wind-Tunnel Design and Test Techniques. H. H. Kurzweg. (Symposium on Experimental Compressible Flow, June 29, 1950.) *U.S. Naval Ordnance Laboratory, Report No. 1133*, May 1, 1950, pp. 103–119, illus.

As the Mach Number increases, the size of wind-tunnel test sections must increase to accommodate for scale effect. Construction costs could be reduced by using grating diffusers, which consist of several small two-dimensional diffuser ducts made of double wedge-shape bars. A 50-ft. diffuser could thus be reduced to a few feet in size. Grating nozzles would produce small wake disturbances and could be made continuously variable over a range of Mach Numbers. They would prevent condensation and eliminate the need for dryer equipment. At high Mach Numbers, the temperature of the tunnel walls must be controlled over a wide range to compensate for radiation exchange between the model and the tunnel walls.

Flow Visualization at Low Pressures. R. G. Folsom. (Symposium on Experimental Compressible Flow, June 29, 1950.) *U.S. Naval Ordnance Laboratory, Report No. 1133*, May 1, 1950, pp. 87–101, illus. 7 references.

An analysis of flow-visualization techniques. The low pressures encountered in the test sections of high-speed wind tunnels and the low atmospheric pressures encountered on the trajectories of high-altitude missiles make impractical conventional flow-visualization methods that depend on the variation in the index of refraction of the air. Experimental work supports the conclusion that this difficulty may be overcome by using the oxygen absorption method. The electrical discharge and afterglow methods for flow visualization in nitrogen have produced satisfactory photographs of the flow fields around objects in wind-tunnel test sections at low absolute pressures.

A New Method of Designing Two-Dimensional Laval Nozzles for a Parallel and Uniform Jet. Kuno Foelsch. *North American Aviation, Inc., Engineering Department, Thermodynamics Section, Report No. NA-46-235-2*, May 27, 1946. 48 pp., illus. 4 references.

An analytical determination of the contours of a two-dimensional nozzle for effecting ideal expansion of gases to a uniform parallel jet which eliminates the laborious graphical construction and the graphical error inherent in the Prandtl-Buseman method. The mathematical equations that are developed permit the immediate determination of the coordinates of any streamline in point-source flow. The equations are extended to permit solution of the flow from the parallel throat section of a laval nozzle.

Development of the Princess; The Work of the Wind Tunnel. D. MacKenzie. *The New Slipway*, Vol. 1, No. 4, June, 1950, pp. 5–8, illus. Saunders-Roe, Ltd.

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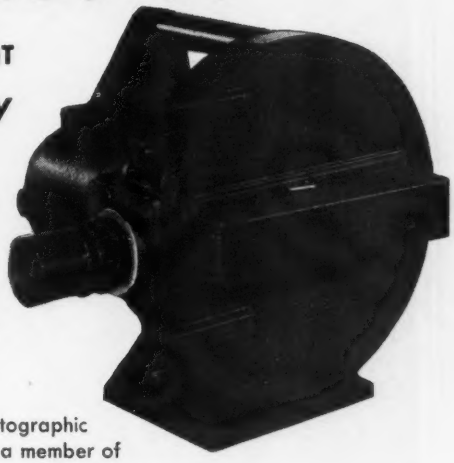

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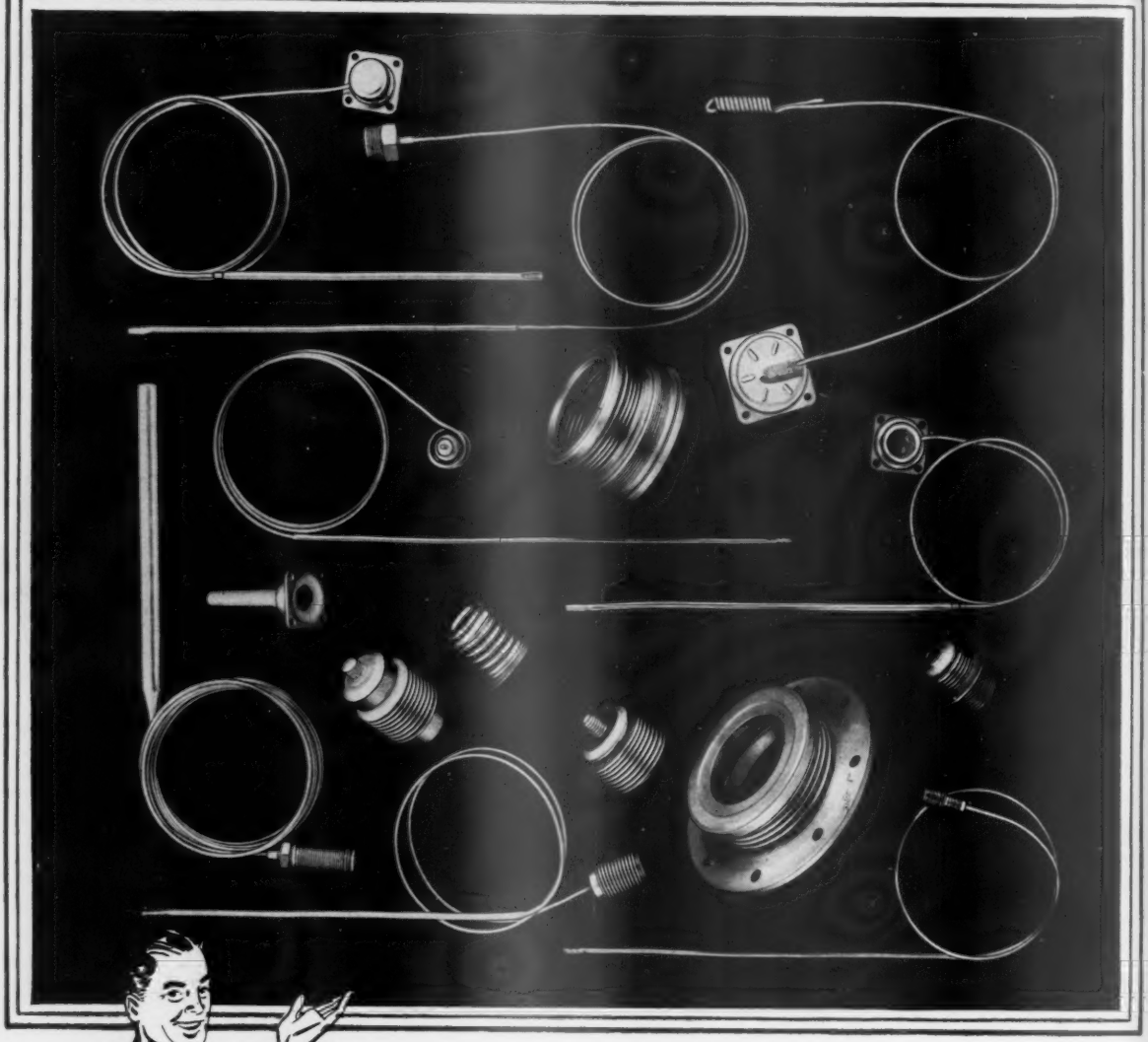

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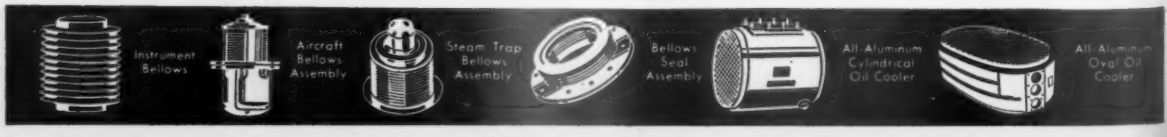

Aeronautical Reviews — BOOKS

Dynamics of Real Fluids

By E. G. Richardson. London, Edward Arnold & Company; New York, Longmans, Green & Company, 1950. 144 pp., figs. $3.75.

This little book by Richardson is an interesting and welcome addition to the literature on fluid mechanics. In 144 pages the author discusses subjects ranging from Stokes' resistance law for spheres to the motion of suspensions, etc. It has become common, at least in the aeronautical literature, to include, under dynamics of ideal or perfect fluids, simply the nonviscous motion of fluids and, under dynamics of real fluids, the simplest viscous motion of a Newtonian fluid. Richardson uses the term "real fluid" in the broader and much more adequate sense.

The book consists of seven chapters. In Chapter 1, "The Classical Approach," the equations of motion are stated and discussed for a Newtonian viscous fluid, and special solutions are obtained. Stokes flow, Oseen flow, and nonviscous flow are sketched. Chapter 2, "Fluids of Small Viscosity," introduces the boundary-layer ideas and discusses wakes, vortex streets, etc. Chapter 3 gives a brief discussion of compressibility effects. Chapter 4 deals with fluids with temperature gradients; Chapter 5, with heavy fluids with free surfaces. Chapters 6 and 7 are devoted to non-Newtonian fluids—i.e., suspensions and elastic liquids.

The level of the book is similar to that of Prandtl's *Strömungslehre;* emphasis and style, however, differ greatly from Prandtl's book. Richardson's book emphasizes the author's own fields of interest and contributions. This fact is, in general, no drawback and makes the reading of the book stimulating. The great virtue of this book, in the opinion of the reviewer, lies in its broad and physical approach. This feature will certainly serve to show students and researchers in fluid mechanics and aeronautics how broad the field of fluid motion actually is. This is often overlooked because of the general tendency toward specialization and also because of the present common, but unfortunate, split between physics, aeronautics, meteorology, hydrodynamics, etc.

Clearly, the book has its shortcomings. In general, it appears to the reviewer that it could stand a certain amount of more careful rephrasing and polishing—e.g., on page 68 it is stated that in Ackeret's recent experiments the Reynolds Number was varied at constant Mach Number by means of flexible test-section walls. On page 80, the statement is reversed, and the Mach Number is now varied by means of flexible walls while the Reynolds Number stays fixed. Actually, both statements are not quite correct and precise. The reviewer also noticed a few slightly more serious misstatements and omissions: The discussion of Tollmien's and Schlichting's work and of the Schubauer-Scramstad experiments misses the point somewhat. The importance of these investigations lies in the fact that they establish the instability of laminar flow with respect to *small* perturbations, and in this they differ essentially from Richardson's, as well as Schiller's, experimental work. In fact, the crux of the stability question was just the question of whether laminar flow was stable with respect to finite or infinitesimal disturbances. In the discussion of boundary layers, the most important feature—namely, that the pressure is constant through the boundary layer—is not stressed sufficiently. In common with many physics texts, the difference between an adiabatic process and an isentropic—i.e., adiabatic reversible process—is not made precise enough. In spite of a fairly extensive discussion of hot wires and optical methods as applied to turbulence measurements, the problem of length correction is not stressed.

However, minor shortcomings such as these are to be expected in the first printing of a book of such wide scope. In general, the author has certainly succeeded in writing a useful, stimulating, and readable book.

HANS W. LIEPMANN
Associate Professor of Aeronautics
California Institute of Technology

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Statements and opinions expressed in Book Reviews are to be understood as individual expressions and not necessarily those of the Institute.

Numerical Analysis of Heat Flow

By G. M. Dusinberre. New York, McGraw-Hill Book Company, Inc., 1949. 227 pp., figs. $4.50.

This is a book for the practicing engineer and for the young engineer who intends to practice. It is written by an engineer who has all the traditional engineering prejudices in favor of methods that give a numerical answer. It is therefore restricted to numerical methods of analysis of heat transfer. The classical analytical methods, which, to be sure, sometimes yield a numerical result, are omitted not only because they have been adequately treated elsewhere but also, it is implied, because they are of too limited utility.

Two general methods are treated in great detail: the relaxation method and the iteration method. The relaxation method, which solves problems in the steady state, the author attributes to Southwell and Emmons, although he points out its close kinship to the methods of Cross in stress analysis. The iteration procedure, which is used for problems in transient flow, he traces from Fourier through Binder, Schmidt, and Nessi and Nissole.

The book begins with elementary considerations and some statements about the artificial points of view that are adopted in the study of heat flow as a matter of expediency. The books of many authors have been left hanging in mid-air for want of such groundwork. Classical methods are discussed and disposed of in short order. Then comes a carefully graded and profusely illustrated presentation of the numerical methods that are the reason for the book.

The problems that are used to illustrate the more advanced phases of the methods are typical engineering problems. They have that degree of complexity that can be surmounted only by technique and art in combination. The artistry involved in bringing order out of the chaos of the original situation becomes evident from the change in method and emphasis with change in situation. Perhaps the value of a book of this sort lies as much in the opportunity to see this artistry at work as in the orderly presentation of powerful tools of engineering analysis and design.

JOSEPH H. KEENAN
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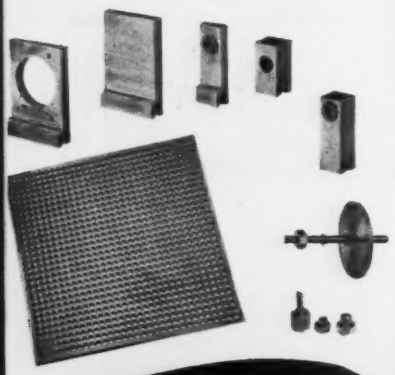

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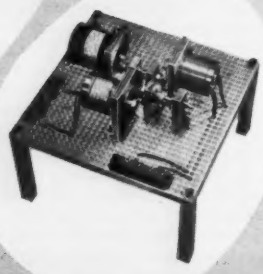

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Photoelasticity

By H. T. Jessop and F. C. Harris. New York, Dover Publications, Inc., 1950. 184 pp., figs. $3.50.

This book is a welcome addition to the available literature on photoelasticity. It brings together in one volume the fundamentals of the photoelastic method of stress analysis and an account of the materials and methods of experimental stress analysis now in use. The authors have concentrated their entire attention on the use of the fundamental principles in the derivation of the standard equations and in the devising of the appropriate methods of procedure.

In the first two chapters a rather comprehensive review of the two-dimensional system of stresses, strains, and the stress-strain relations is taken up. A portion is devoted to the presentation of the Theory of Generalized Plane Stress and also touches upon the Laplace's Equation for the Sum of the Principal Stresses.

The nature of light and a consideration of elementary optics are taken up in two succeeding chapters. In these are included such topics as reflection, refraction, periodic motion, wave theory, polarization, and double refraction. Space is devoted to items such as dispersion, interference, and mechanism of operation of crystals and compensators.

The next chapter begins the actual interpretation of the photoelastic phenomena by dealing with the determination of the isoclinic lines and stress trajectories from observations with a polariscope. The next chapter deals with the reduction and interpretation of the observations. Here is found a rather complete treatment for the practical user. Information is given on the various types of isotropic points and the layout of the trajectories in their locations. The treatment also covers the separation of the principal stresses or the determination of the normal and shear stresses across a section. The methods discussed are the graphical-integration method of Filon for working along a stress trajectory, the shear-difference method for the arithmetic integration along an arbitrarily chosen straight line, Frocht's slope-equilibrium method, and the application of Laplace's Equation to the sum of the principal stresses.

The next chapter deals briefly with the photoelasticity investigation of three-dimensional systems with emphasis on the outline of the "frozen-stress" method. So far this method is by far the only one showing any promise of being of any practical value Because of its insufficient development, it was deemed justifiable to indicate the general procedure to be followed in its use.

The following chapters are devoted to practical considerations. The authors discuss the various techniques used to obtain photoelastic observations and the photoelastic materials and their properties. This is supplemented with comments from actual experience on the preparation of test models.

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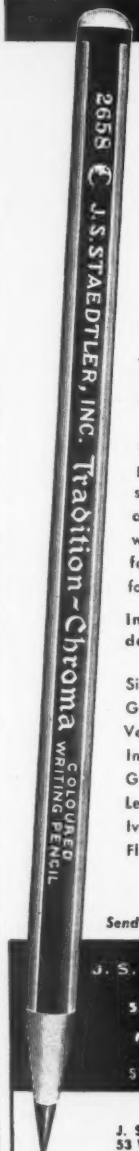

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The book also contains a series of examples for use as illustrations of the various methods of interpretation and reduction of observations, which should be of considerable assistance to the practical engineer.

This book is a tribute to the authors, who have managed to collect together all available useful hints and suggestions obtained from actual experience for those who wish to undertake experimental stress analysis without risk of serious error.

To the publishers must be given credit for the splendid presentation and printing of the book.

HARRY ZUCKERBERG
Professional Engineer
New York

Elements of Internal Combustion Turbine Theory

By H. T. Adams. Cambridge and New York, Cambridge University Press, 1949. 176 pp., figs. $3.75.

Some of the theory and methods employed in the design of the internal-combustion turbine are presented in this book in a rather simple form. The book, as is stated by the author, is intended for the use of advanced students or engineers unfamiliar with this branch of their profession. The book is based in part on a previous work of the same author published in Great Britain by H. M. Stationery Office which bears the title *The Aircraft Gas Turbine.*

If one examines the book carefully, he will find a mixture of "garden variety" fluid dynamics and thermodynamics together with much useful empirical data which could have come only from the author's association as Director of Studies with Power Jets Ltd. under the British Ministry of Aircraft Production. Chapter I contains the "oft-repeated" history of the gas turbine, while Chapter II contains the usual thermodynamic formulas covering the equation of state, gas mixtures, entropy, polytropics, cycles, flow through nozzles, velocity of sound, etc. The real value of the book is to be found in the empirical statements made throughout the book. For instance, in Chapter III on centrifugal compressors, the author states: "For a single stage the maximum economic pressure ratio, as will appear later, is in the region of 4–4.5. With present designs the maximum efficiency under operational conditions appears to be 75–78%." Many other statements based on the author's experience are given, without proof, throughout the book.

Another example is found in the discussion of surging of compressors: "The frequency of the surge will depend upon the size of the receiver, since the larger this is the slower will be the rate of pressure rise." In this way, the author has covered in not too rigorous a fashion the many results of much experience in the design and construction of turbojet engines.

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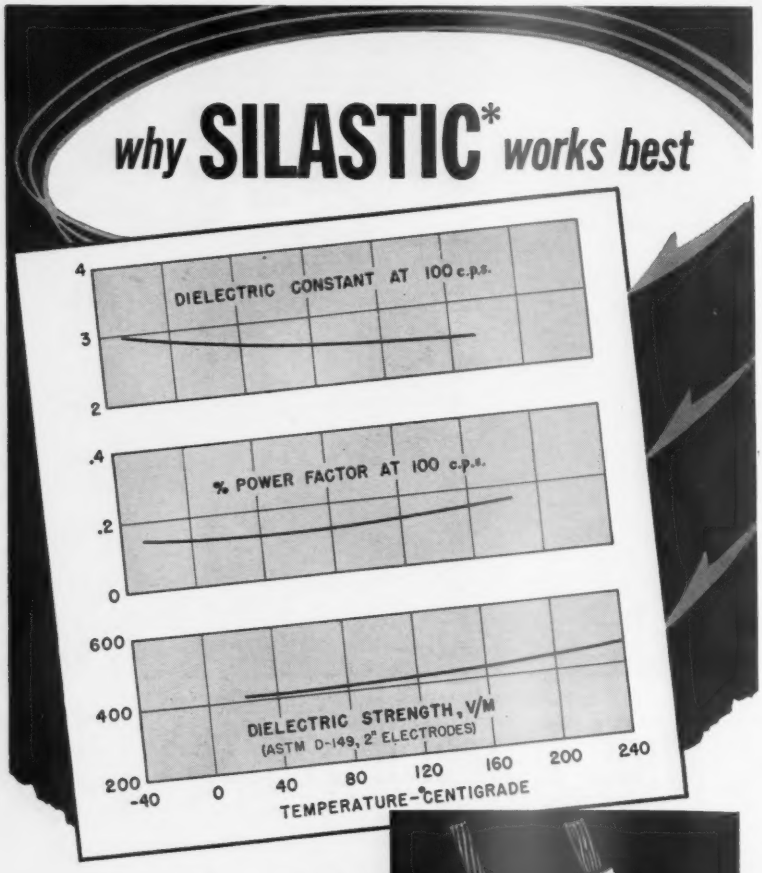

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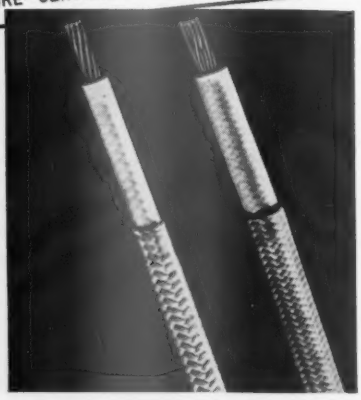

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The remaining chapters of the book cover in detail the axial-flow compressor, the turbine, stress calculations, vibrations, critical speeds and end loads, test data correction, and, lastly, heat exchangers and intercoolers. In general, one would say that the book contains a large amount of useful know-how. Many numerical examples and calculation tables are given throughout the book indicating the detailed methods of designing centrifugal and axial-flow compressors and turbines. The temperature-entropy and air-velocity charts contained in the back of the book are so small that they could hardly be expected to be of any practical use. They therefore give a poor impression of an otherwise useful book.

C. A. MEYER
Thermodynamic Section Engineer
Aviation Gas Turbine Division
Westinghouse Electric Corporation

Frictional Phenomena

By Andrew Gemant. Brooklyn, N.Y., Chemical Publishing Company, Inc., 1950. 497 pp., figs. $12.

The bulk of this book is primarily an edited and enlarged version of a series of articles written by the author which were published in the *Journal of Applied Physics* from 1941 to 1943. Frictional processes in all fields of engineering, such as gaseous viscosity, acoustic absorbents, liquid viscometry, viscosity of colloids and gels, plastic flow, ionic conduction in solids, and damping of vibrations, are treated in a clear and simple manner in this volume. Throughout the book, emphasis has been made on the physical interpretation of these frictional phenomena. It presents in detail the experimental results and engineering applications. Brief and elementary theoretical formulations of the problems are included, but its understanding does not require an advanced mathematical background.

The book is divided into five parts. The first part consists of two introductory chapters that include a review of the concept of friction and an outline of the mathematical treatment of frictional process. The second part treats the frictional processes in gases and contains three chapters. Chapter 3 gives an outline of kinetic theory, theory of slip, and experimental facts. Chapter 4 discusses the absorption of sonic and ultrasonic waves and is followed up by a chapter on sound-absorbing materials. The viscous flow of gases has been left out in this part because, as the author pointed out, it will be more convenient to treat it after the discussion of the flow of liquids.

The next seven chapters make up the third part of the book in which the frictional processes in liquid and colloidal solutions are discussed. These seven chapters give an outline of the general theory and experimental facts, the various types of viscometers, acoustic absorption in liquids, viscosity of colloidal solutions and the application to

synthetic polymers, structural viscosity of oil, non-Newtonian behavior with regard to gel-forming colloidal systems, viscous flow of liquids and gases, applications of liquid viscosity to electrical-insulating liquids, particularly in high-voltage cables, and lubrication.

The discussion of frictional processes in solids, which is part four of the book, is taken up in nine chapters. Chapter 13 gives the theory and experimental results on the plastic flow of solids, and Chapter 15 discusses the engineering applications, such as molding of plastics, annealing of glass, lead sheath in high-voltage cables, and ionic conductivity of solid insulating materials. Chapter 14 discusses the correlation between elastic moduli and viscosity of liquids and plastic solids. Chapter 16 presents a general outline of internal friction of solids, the experimental results, and interpretation. This is followed by a chapter on the engineering applications, such as whipping of rotating shafts, metallurgical applications, damping in automobile tires, and dielectric losses in solid insulating material. Chapter 18 deals with the reduction of vibrations by use of materials of high damping capacity, and Chapter 19 with the stress-dependent plastic resistance and damping capacity of alloys. The discussion on frictional process in solids concludes with two chapters on the external friction and its engineering application, which includes such topics as belt drives, brakes, vibration dampers, self-excited vibrations, and the so-called "frictional electricity."

No problems or illustrative examples for calculation are given in the text but are collected, with solutions, in the last part of the volume. The readers will find these illustrative examples helpful to the understanding of the treatise.

Dr. C. T. Wang
Associate Professor of
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College of Engineering
New York University

Interplanetary Flight; An Introduction to Astronautics

By Arthur C. Clarke. London, Temple Press, Ltd., 1950. 164 pp., illus. 8s. 6d.

This pocket-sized volume provides a handy tabulation and description of some of the problems of interplanetary flight. It is written somewhat in the same semitechnical style as previous books on the subject by Lasser, Cleator, Pendray, and Ley. In his introduction, Mr. Clarke forewarns the reader who might expect too much that the approach is "from the astronomical rather than the engineering point of view" and that "the science of 'astronautics' still belongs to the future."

Nevertheless, various small groups of individuals with an imaginative turn of mind have been investigating the problem of space navigation, or "astronautics," for many years, and especially during the past three decades. The principal groups included the Verein für Raumschiffahrt (Society for Space Navigation) which was organized in Germany in 1927 (and dissolved in 1933 by the Nazi government probably to keep V-2 development plans from leaking out); the American Interplanetary Society, organized in the United States in 1930 (the name was changed to the more prosaic American Rocket Society in 1934 to enlist wider support in solving the simpler terrestrial rocket problem first); and the British Interplanetary Society (B.I.S.), which picked up the wavering interplanetary banner in the same year and has since ably carried on.

Mr. Clarke is Assistant Secretary of the B.I.S. While the treatment is that of the author, the subject matter reflects the long discussions on interplanetary considerations that were the subject of many meetings of this group.

After a brief historical survey of the contributions of early rocket pioneers, the author presents the equations of celestial mechanics which are needed to determine "escape velocity" from the earth and the other planets, and to make various "round trips." Since the laws of astronomy are not likely to change for a while, these considerations of the minimum energy required to overcome gravitational attractions on an interplanetary trip are as accurate now as they probably ever will be, regardless of the method to be used to develop that energy.

A chapter on "The Rocket" summarizes the progress made in the past decade resulting in such examples as the V-2, the Wac Corporal, the Viking, and other types. It also summarizes the magnitude of the work still to be done to bridge the gap to the true space-rocket. Another chapter discusses the atomic rocket as a possible answer when heat transfer and radiation problems are solved. A mathematical appendix showing derivation of various pertinent equations completes the discussion.

This book is recommended reading for the intelligent layman who would like to be informed on what has to be done to make interplanetary flight a reality. It should be read for its sobering effect—especially by those who have been talking "push buttons," interplanetary, or otherwise.

Alfred Africano
Staff Engineer, Rocket Department
Propeller Division
Curtiss-Wright Corporation

Book Notes

AERODYNAMICS

Symposium on Experimental Compressible Flow. (U.S. Naval Ordnance Laboratory, Report No. 1133.) White Oak, Md., Naval Ordnance Laboratory, 1949. 119 pp., illus., diagrs.

Contents: Methods for Investigation of Flows at Transonic Speeds, John Stack. Boundary-Layer Shock-Wave Interaction, H. W. Liepmann. Interferometric Studies on Laminar and Turbulent Boundary Layers Along a Plane Surface at Supersonic Velocities, R. Ladenburg and D. Bershader. Flow Visualization at Low Pressures, R. G. Folsom. A Few Aspects of Future Supersonic Wind-Tunnel Design and Test Technique, H. H. Kurzweg.

Addresses at the Dedication of the NOL Aeroballistic Research Facilities, and at the General Session on Aeromechanics Research. (U.S. Naval Ordnance Laboratory, Report No. 1130.) White Oak, Md., Naval Ordnance Laboratory, 1949. 98 pp., illus., diagrs.

Contents: Welcome, F. E. Beatty. Presentation of the Aeroballistic Research Facilities, A. G. Noble. Response, R. D. Bennett. Fluid Dynamics and Applied Mathematics Institute at the University of Maryland, H. C. Byrd. Science and National Strength; Some Lessons from World War II, K. T. Compton. Introductory Remarks on Aeromechanics Research, R. J. Seeger. Borderline Regions Between Aerodynamics and Physics, J. M. Burgers. Status and Trend of Applied Research in Ballistics and Supersonic Aerodynamics, H. L. Dryden.

Handbook of Supersonic Aerodynamics. (U.S. Navy Department, Bureau of Ordnance, NAVORD Report No. 1488, Vol. 1.) Washington, U.S. Govt. Printing Office, 1950. 390 pp., diagrs.

This handbook originated in the Aerodynamics Group at the Applied Physics Laboratory of The Johns Hopkins University, when work on the Bumblebee (ram-jet) project was begun late in 1945. Sections were distributed in 1946, and late that year a separate Aerodynamics Handbook Project was set up. A second edition of the Handbook was distributed early in 1949. The Bureau of Ordnance undertook the printing and distribution in February, 1950, with editorial responsibility remaining with the Applied Physics Laboratory. The first section (21 pages) deals with Symbols and Nomenclature. Section 2 (35 pages, 9 references) is concerned with Fundamental Equations and Formulae. Section 3 (123 pages, 91 references) covers General Atmospheric Data, and Section 4 (155 pages, 18 references) covers Mechanics and Thermodynamics of Steady One-Dimensional Gas Flow. Sections 1 and 3 are revised from the 1949 edition, and Sections 2 and 4 are reprinted without change.

AERONAUTICS, GENERAL

Verslagen en Verhandlingen (Reports and Transactions), Vol. 13, 1947. Amsterdam, National Luchtvaartlaboratorium, 1950. 238 pp., illus.

The reports in this first postwar volume, with one exception, are in English, in accordance with the decision of the Laboratory to publish all reports in English beginning about 1945.

Contents: A.950, Drag and Pressure Measurements with Plaster Spheres in Windtunnel 3 and 4 of the National Aeronautical Research Institute, S. I. Wiselius. A.1011, Some Remarks About High-Frequency Rotary-Current Electric Motors for Driving Model Propellers, J. G. Slotboom. S.311, Calculation of the Deformation of Two-Spar Wings with Shear-Resistant Skin, F. J. Plantema and A. Van Der Neut. S.326, Supplement to the Method of Wing Analysis Developed in Reports S.251 and S.279 (Vol. 12). S.280, Collapsing Stresses of Circular Cylinders and Round Tubes, F. J. Plantema. S.319, The Elastic Stability of Flat Sandwich Plates, A. Van Wijngaarden. S.314, The General Instability of Stiffened Cylindrical Shells Under Axial Compression, A. Van Der Neut. V.1297, Diagrams of Critical Flutter Speed for Wings of a Certain Standard Type, A. I. Van De Vooren and J. H. Greidanus. V.1286, Benaderende Methode voor het Berekenen van de voor het Landen van een Vliegtuig Vereischte Hoogteroeruitslagen en

van de Meest Voorlijke Ligging van het Zwaartepunt, Welke met het Oog op het Landen Toelaatbaar Is, A. J. Marx. V.1380, The Change in Flutter Speed Due to Small Variations in Some Aileron Parameters, A. I. Van De Vooren. V.1397, Diagrams of Flutter, Divergence and Aileron Reversal Speeds for Wings of a Certain Standard Type, A. I. Van De Vooren. V.1366, A Method to Determine the Change in Flutter Speed Due to Small Changes in the Mechanical System, A. I. Van De Vooren. V.1384, Mathematical Methods of Flutter Analysis, J. H. Greidanus. V.1386, The Treatment of a Tab in Flutter Calculations Including a Complete Account of Aerodynamic Coefficients, A. I. Van De Vooren.

AIR TRANSPORTATION

Economics of Transportation. Marvin L. Fair and Ernest W. Williams, Jr. New York, Harper & Bros., 1950. 757 pp. $5.50.

The emphasis in this textbook is upon the function of transportation in the economic system, its contribution to the system, the development of facilities, services, and rate structures in response to demand and under regulatory government bodies, and considerations involved in the evaluation of an integrated transportation service. The five parts of the book deal with transportation development, service, rates, regulation and national policy, covering rail, air, water, highway, and pipe-line transportation in each part. Footnote references and chapter bibliographies are included throughout. The senior author is a professor of economics at Tulane University and Mr. Williams is a lecturer in transportation at Columbia University.

Official Air Cargo Station Directory. Washington, Air Cargo, Inc., 1949. 49 pp. $10 per year.

The purpose is to provide a course of ready reference data on the air-cargo facilities and operational policies of the 23 scheduled trunk and feeder air lines participating. The first section gives general information on maximum package sizes, weights, and valuations that are acceptable without advance arrangement on carriers. Airplanes flown by each carrier and a summary of terms of acceptance of unusual shipments, including live freight, are included in this section. The second section lists, by city, the types of aircraft flown through each by carriers, local handling equipment, transfer facilities to rail or motor freight, weights and sizes of packages accepted without advance arrangement, U.S. customs facilities, and special information on embargoes, etc. The operating schedules of all exclusive cargo flights and the types of aircraft used on them are given for each carrier in the third section.

FLIGHT OPERATING PROBLEMS

Flight Engineering. Clifford H. Karvineu. St. Louis, Educational Publishers, Inc., 1949. 158 pp., illus., diagrs. $3.75.

Intended as an introduction to the subject, this book discusses the qualifications, training, and duties of the flight engineer; engine power and related variables; operating power curves and charts; supercharged engines; weights, loading, and balance; and airplane performance and cruise control. The text of the appropriate *Civil Air Regulations* and various conversion tables and related study data are included. The author is with the Parks College of Aeronautical Technology of St. Louis University.

FUELS & LUBRICANTS

Motor Oils and Engine Lubrication. Carl W. Georgi. New York, Reinhold Publishing Corporation, 1950. 514 pp., illus., diagrs. $8.50.

The author's purpose is to present a summary of existing information on motor oils and their use in lubricating internal-combustion engines. The first half of the book deals with the manufacture of motor oils, their chemical and physical properties, testing methods, and evaluation of performance characteristics of motor oils. The second half is concerned with the uses of motor oils, and the relation of oils and lubrication to design, operation, and maintenance. The book ends with chapters on lubrication of aircraft reciprocating engines, Diesel engines, and stationary, marine, and two-cycle engines. Bibliographies are given at the ends of chapters. The author is technical director of the research laboratories of the Quaker State Oil Refining Corporation.

INSTRUMENTS

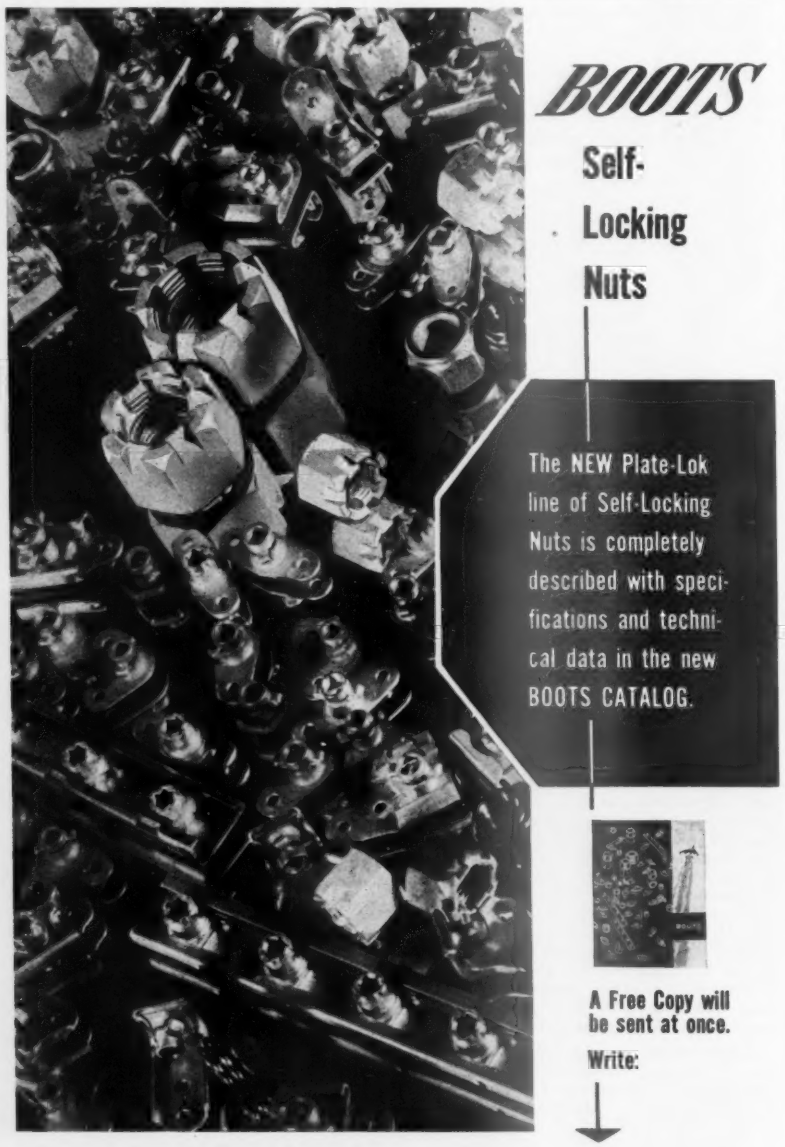
Industrial Instrumentation. Donald P. Eckman. New York, John Wiley & Sons, Inc., 1950. 396 pp., illus., diagrs. $5.00.

The purpose of this book is to review the methods of measurement used in industrial processing and manufacturing, with emphasis on the method rather than the mechanism with which it is done. As it is intended for engineering undergraduates, physical principles are reviewed to focus attention on the engineering applications, and to induce an analytical approach to measurement problems. Expansion and resistance thermometers, thermoelectric and radiation temperature measurement, spectroscopy, gas analysis, measurement of moisture in gases and solids, mechanical measurements, measurement of pressure and vacuum, and head and level, flowmetering, and recording, indicating and signaling, and other types of process instrumentation are among the topics discussed. Useful tables are given in an appendix. The author is a teaching fellow at Cornell University and consultant to the Conoflow Corporation.

MATERIALS

The Inelastic Behavior of Engineering Materials and Structures. Alfred H. Freudenthal. New York, John Wiley & Sons, Inc., 1950. 587 pp., illus., diagrs. $7.50.

In this textbook for graduate engineering students, an integration is made of the response to applied forces of engineering materials, through a combination of the physical (structural) and the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engineering (phenomenological) approaches. The physical response to forces, time, and temperature of engineering materials receives the main emphasis, in order to provide a more effective approach to the study of real materials. The discrepancy between the elaborate aerodynamic analysis of the airplane or the thermodynamic analysis of the gas turbine and the crudeness of the concepts and methods used in proportioning their parts, and the proposed extension of the concept of the elastic stress concentration around a hole to cracks of submicroscopic size, are cited as examples of the handling of engineering reality in terms of only the resistance of the continuous elastic medium. The increase in complexity of materials and of the conditions of their service requires consideration of their structure and their phenomenological response in terms of structural changes under the applied forces and conditions. The first part of the book deals with The Structural Aspect of Mechanical Behavior, including considerations of the structure of matter and structural theories of deformation. The second part, on the Mechanics of Inelastic Deformation, continues the development of the theory of inelasticity, and the third part, Applications of the Mechanics of Inelastic Behavior, considers selected problems of the mechanics of the inelastic continuum, the design of engineering structures, and mechanical testing. The book is based on lecture notes prepared for graduate students at the University of Illinois and later repeated at Columbia University, where Professor Freudenthal teaches. References are given at the ends of chapters, and indexes of authors and subjects are provided.

Properties of Metals at Elevated Temperatures. George V. Smith. New York, McGraw-Hill Book Company, Inc., 1950. 401 pp., illus., diagrs. $7.00.

Though considerable research has been carried out on the fundamental mechanisms of plastic deformation under stress at high temperatures, and on the effect of grain size, recrystallization, distribution of the phases, and phase changes, this is the first attempt in this country to correlate these investigations. Following fundamental considerations of plastic flow and fracture, test apparatus and procedures for elevated temperature service are taken up, and the effects of various variables, changes occurring during service, and design for high-temperature service. An appendix on superalloys is contributed by H. F. Miller of the Carnegie-Illinois Steel Corporation, with 59 references. A bibliography of 488 references concludes the book. The author is associated with the research laboratory of the United States Steel Corporation.

1950 Modern Plastics Encyclopedia and Engineer's Handbook. New York, Plastics Catalogue Corporation, 1950. 1212 pp., illus. $3.00.

The first 538 pages of this year's edition are concerned with engineering, including molding design factors, molding, extruding and casting, fabricating and finishing, and machines and machine tools. The materials section of 358 pages covers recent developments, history, chemistry, general characteristics and applications of types of plastics from acrylics to vinyl polymers, including film and sheeting, adhesives, and laminates. The technical section of 106 pages includes a number of charts and bibliographies of properties, testing, and applications, and a general list of books and magazines. The directory section is complete, and the indexing and arrangement of the book are excellent.

POWER PLANTS

Aircraft Engines of the World, 1950. Paul H. Wilkinson. New York, The Author, 1950. 324 pp., illus. $10.

This year's edition contains 40 standardized descriptions of main gas-turbine power plants, of which 14 are new and 16 revised. The Allison T-38 and T-40, General Electric J-47, Pratt & Whitney J-48, Armstrong Siddeley Adder, Bristol Theseus 502, de Havilland Goblin 4, Napier Coupled Naiad, Rolls-Royce Avon, Avro Canada Orenda, S.N.E.C.M.A. TB-1000, Turboméca Piméné, and Svenska Flygmotor Ghost are among the new descriptions. The R-509 rocketjet is the latest Russian engine in this section. In the auxiliary section, seven American, one British, and one French gas turbines and thrust augmentors are described. The reciprocating engine section includes 93 engines from 10 countries, including compounded and helicopter engines. Tabulations of the principal power plants for comparative purposes and indexes to jet and reciprocating engines are included.

JET & TURBINE

Steam and Gas Turbines. Bernhardt G. A. Skrotzki and William A. Vopat. New York, McGraw-Hill Book Company, Inc., 1950. 395 pp., illus., diagrs. $5.00.

This book deals with turbine behavior as applied to stationary power generation. The greater part of the book is concerned with the operation and maintenance of the steam turbine, with separate chapters on lubrication, steam fundamentals, heat performance, governors, and auxiliaries. The final chapter deals with gas turbines. The senior author is Associate Editor of *Power*, in which some of the material in the book was published in 1945 and 1946. Professor Vopat is head of the Department of Mechanical Engineering at the Cooper Union, New York.

RECIPROCATING

Aircraft Engine Maintenance and Service. Rollen H. Drake. New York, The Macmillan Company, 1950. 237 pp., illus., diagrs. $5.00.

Various types of inspections necessary to keep aircraft reciprocating engines and propellers in safe operating condition are covered completely, with separate chapters on inspection procedures, periodic inspections, trouble shooting, and overhaul and magnetic inspection. Fuel, lubrication, ignition, cooling, and induction systems are described, and procedures for engine overhaul, disassembly, cleaning and refinishing, repair and replacement, assembly, installation, run-in, and storage are described. There is a separate chapter on propeller maintenance and service. The simply written text is accompanied by numerous excellent drawings and photographs.

ROCKET

Internal Ballistics of Solid-Fuel Rockets. R. N. Wimpress. New York, McGraw-Hill Book Company, Inc., 1950. 214 pp., illus., diagrs. $4.50.

The work of The Propellants Group of the rocket development organization at the California Institute of Technology, working from 1941 to 1945 under contract with the Office of Scientific Research and Development, is systematically integrated in this book. As the work was concerned with internal ballistics of artillery rockets and with the use of dry-processed double-base propellants, the book is devoted largely to these topics as approached by the group. Chapters on the Steady-State Flow of Compressible Fluids, Nozzle Performance, Flow of Gas Inside Rocket Motors, Determination of Reaction Pressures in Rocket Motors, and Heat Transfer, while dealing with the specific fields mentioned, are also of general interest. The characteristics of propellant gases, burning properties of propellants, design of propellant grains, characteristics of burning in perforations, ignition, end-burning grains, static-testing equipment, and the effect of physical properties of propellants on ballistic performance are among the other topics discussed. No bibliography or references are provided since material of confidential nature would be involved. The author, formerly with the group, is now with Industrial Engineers, Inc.

PRODUCTION

Welding, Brazing, and Soldering. Chicago, Popular Mechanics Company, 1949. 95 pp., illus. $1.25.

The 20 articles reprinted here from *Popular Mechanics* cover methods of welding, brazing, and soldering in a readable and lucid manner, with profuse clear illustrations plainly labeled. Stainless steel and aluminum are among the materials discussed, and emphasis is placed on methods using available types of equipment to keep costs down.

SCIENCES, GENERAL

MATHEMATICS

Some Theory of Sampling. William Edwards Deming. New York, John Wiley & Sons, Inc., 1950. 602 pp., diagrs. $9.00.

Designed for the engineering and industrial management student and specialist, as well as students in the social sciences and commerce, this textbook deals with statistical sampling methods and theory. A knowledge of mathematical statistics is required of the reader, and the engineering student should be already familiar with statistical quality control and the design of experiments. The author is an advisor to the Bureau of the Budget and Adjunct Professor of Statistics in the Graduate School of New York University.

Elements of Ordinary Differential Equations. Michael Golomb and Merrill Shanks. New York, McGraw-Hill Book Company, Inc., 1950. 356 pp. $3.50.

Intended for a first course in ordinary differential equations, this textbook includes enough material for its use in a more advanced course. Designed for engineering, science, and mathematics students, the book emphasizes physical principles. Geometric and numerical methods are emphasized in the early chapters, proceeding to a more systematic and deductive approach. Linear equations are dealt with almost exclusively. Elementary treatments are included of operational calculus and power series, and other features include use of the superposition principle, use of existence theorems in development of techniques, use of Green's functions, and treatment of systems of equations without the use of matrices. The authors are Associate Professors respectively of Mathematics and Mathematics and Aeronautical Engineering at Purdue University.

Analytic Geometry and Calculus. Harold J. Gay. Edited by Raymond K. Morley. New York, McGraw-Hill Book Company, Inc., 1950. 524 pp. $5.00.

Material usually included in a first course in both analytic geometry and calculus is covered in this textbook, correlated to show the applications of each to the other. Plane analytic geometry and differential and integral calculus are covered in the first half of the book, proceeding into solid analytic geometry and calculus, including elementary differential equations. The discussion proceeds according to kinds of functions, from algebraic functions and their simpler applications to logarithmic and trigonometric functions, with their graphs, derivatives, and integrals. Numerous problems are provided with selected answers. The late Professor Gay was with the Worcester Polytechnic Institute, and Professor Morley teaches there.

MECHANICS

Applied Mechanics: Dynamics. George W. Housner and Donald E. Hudson. New York, D. Van Nostrand Company, Inc., 1950. 295 pp. diagrs. $4.50.

Designed for third-year engineering students, this textbook presents a broader point of view than is usually given in undergraduate courses in engineering mechanics, including the elements of dimensional analysis, the theory of mechanical vibrations, the mechanical-electrical analogy, the energy equation and development of the momentum-transfer equations for a fluid, and some discussion of electron motion. The simplest notions are reviewed in the first chapters, proceeding into the dynamics of a particle, systems of particles, rigid bodies, and nonrigid systems of particles. Methods of advanced dynamics are discussed in the final chapter. About 300 problems are included, with answers to most of them. The authors are on the faculty of the Division of Engineering at the California Institute of Technology.

Physical Mechanics. Robert Bruce Lindsay. 2nd Ed. New York, D. Van Nostrand Company, Inc., 1950. 451 pp., diagrs. $5.00.

In this new edition of an intermediate textbook first published in 1933, new material has been added on atomic theory, relaxation phenomena, motion in resisting media, kinetic theory, and oscillations, and the mechanics of a rigid body is discussed in a single chapter emphasizing the dynamical approach, with statics brought in as a special case. Revisions have been made to bring introductory material on the idea of energy, collision phenomena, and material on advanced mechanics and wave mechanics into more logical order, and the problems have been revised and expanded. The author is Hazard Professor of Physics at Brown University.

PHYSICS

Physics, Fundamental Principles for Students of Science and Engineering. George Shortley and Dudley Williams. New York, Prentice-Hall, Inc., 1950. 2 Vols. 1271 pp., diagrs. Vol. 1, $5.65; Vol. 2, $6.65.

This textbook is intended for second year students of science and engineering who are studying the calculus concurrently. The first volume deals with mechanics and heat, including such applications as elasticity and strength of materials, impacts and conservation of momentum, vibratory motion, fluid dynamics, and gyroscopic motion. The second volume takes up wave motion, sound, light, electricity and magnetism, and modern physics, including electronics, electromagnetic waves, and elementary particles. The gravitational British-engineering system is used when English units are involved, and the meter-kilogram-second system where international metric units are involved. Other systems and conversion tables are given in appendixes. The authors are respectively a Professor and Associate Professor of Physics at the Ohio State University.

Electromagnetic Theory. Oliver Heaviside. New York, Dover Publications, Inc., 1950. 386 pp. $7.50.

This excellent reprint of Heaviside's masterpiece, originally published between 1893 and 1912, contains a 26-page introduction on the life and contributions of the author. Heaviside's chapters on vector analysis and the calculus of operations, almost half of the book; were among his major contributions to mathematical method. The introduction contains more than 65 references to books and papers showing the further development of Heaviside's contributions.

SPACE TRAVEL

Dawn of the Space Age. Harry Harper. London, Sampson Low, Marston & Company, Ltd.; New York, Macdonald & Company (Publishers) Ltd., 1950. 142 pp., illus. $2.20.

The history of the rocket and of rocket research is outlined in the first part, from its beginnings to the end of World War II and the advent of atomic power. The second part, on the objectives of space flight, summarizes the results to date of astronomical research on the moon, Venus, and Mars. In the final part, the present state of knowledge on space-ship design and construction is reviewed, with particular reference to the work of the British Interplanetary Society. This book, by one of the earliest of British aviation writers, is approved as a nontechnical presentation by the technical advisory committee of the British Interplanetary Society.

STRUCTURES

An Introduction to Distribution Methods of Structural Analysis. R. W. Steed. London, Sir Isaac Pitman & Sons, Ltd., 1950. 116 pp., diagrs. 12*s.* 6*d.*

The author's purpose is to provide an introductory work on the analysis of redundant structures by moment distribution methods. An introductory chapter on built-in, or fixed-end, beam theory is followed by discussions of the moment distribution method as applied to continuous beams, portal frames, and redundant pin-pointed frames. The author is a lecturer in civil and mechanical engineering at King's College, London.

THERMODYNAMICS

Heat and Temperature Measurement. Robert L. Weber. New York, Prentice-Hall, Inc., 1950. 422 pp., illus., diagrs. $7.35.

Methods of heat and temperature measurement are described, and the theory necessary for their appreciation, use, and further application is discussed. Experimental methods rather than theory, however, are emphasized. An introductory course in physics is required of the reader. The first part, of 274 pages, presents the physical principles, with examples, and references are given in each chapter for supplementary reading. The second part outlines procedures for 29 laboratory experiments. Various tables and aids to study are given in an appendix. The author is Associate Professor of Physics at the Pennsylvania State College.

Special I.A.S. Publications

Sherman M. Fairchild Publication Fund Papers

No.		Member Price	Nonmember Price
FF-3	The Penetration of a Fluid Surface by a Wedge—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
FF-2	A Study of the Flow, Pressures, and Loads Pertaining to Prismatic Vee-Planing Surfaces—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
FF-1	Ice Protection for Turbojet Transport Airplane (In Three Parts)—P. T. Hacker, R. G. Dorsch, T. F. Gelder, J. P. Lewis, H. C. Chandler, Jr., and S. L. Koutz.	$0.75	$1.25
286	Linearized Treatment of Supersonic Flow Through Axi-Symmetric Ducts with Prescribed Wall Contours—Charles E. Mack, Jr., and Ignace I. Kolodner.	$0.75	$1.25
244	Wetted Area and Center of Pressure of Planing Surfaces—Experimental Towing Tank, Stevens Institute of Technology.	$0.75	$1.00
229	Wave Profile of a Vee-Planing Surface, Including Test Data on a 300 Deadrise Surface—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
170	Wave Contours in the Wake of a 10° Deadrise Planing Surface—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
169	The Discontinuous Fluid Flow Past an Immersed Wedge—Experimental Towing Tank, Stevens Institute of Technology.	$0.75	$1.00
168	Wave Contours in the Wake of a 20° Deadrise Planing Surface—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
167	On the Pressure Distribution for a Wedge Penetrating a Fluid Surface—Experimental Towing Tank, Stevens Institute of Technology.	$0.75	$1.00
66	An Analysis of the Fluid Flow in the Spray Root and Wake Regions of Flat Planing Surfaces—Experimental Towing Tank, Stevens Institute of Technology.	$1.20	$1.60
165	Theory and Practice of Sandwich Construction in Aircraft (A Symposium).	$1.85	$2.50
164	Applications of the Theory of Free Molecule Flow to Aeronautics—Holt Ashley.	$1.15	$1.50
106	Measurement of Ambient Air Temperature in Flight—W. Lavern Howland.	$0.35	$0.50
105	An Evaluation of the Importance of Fatigue Phenomena in Aircraft—C. R. Strang, L. R. Jackson, L. F. McBrearty, R. V. Rhode, and R. L. Schleicher.	$0.80	$1.10
104	Tensor Analysis of Aircraft Structural Vibration—Charles E. Mack, Jr.	$1.85	$2.50
102	Electrical Resistance Strain Gages Applied to Wind-Tunnel Balances—Elmer C. Lundquist.	$0.60	$0.80
101	Introduction to Shock Wave Theory—J. G. Coffin.	$2.65	$3.50
100	Blade Pitching Moments of a Two Bladed Rotor—R. W. Allen	$0.75	$1.00
126	External Sound Levels of Aircraft—R. L. Field, T. M. Edwards, Pell Kangas, and G. L. Pigman	$0.75	$1.00

I.A.S. Preprints

Preprints of I.A.S. Meeting Papers Currently Available

(All produced in accordance with new format except those marked with an asterisk)*

		Member Price	Nonmember Price
305	Dynamic Analysis of Aeroelastic Aircraft by Transfer Function-Fourier Methods—James B. Rea.	$0.35	$0.75
304	Aeroelastic Problems in a High-Speed Bomber—E. S. Hodder.	0.35	0.75
303	Some Roll Characteristics of Cruciform Delta Wings at Supersonic Speeds—Z. O. Bleviss.	0.35	0.75
298	Operating Problems of Turbine-Powered Aircraft—R. D. Kelly.	0.35	0.75
297	The Application of Pressure Refueling to Flight—G. E. Woods-Humphery.	0.35	0.75
296	Supersonic Wing-Body Lift—George Morikawa.	0.50	0.75
295	Current Turboprop Power-Plant Installations—F. H. Sharp.	0.35	0.75
294	Progress In Stall Research—Graham Campbell and Gifford Bull.	0.50	0.75
293	A Method of Presenting the Performance of Turbojet Engines—C. A. Meyer and H. L. Faught.	0.35	0.75
292	A Superposition Method for Calculating the Aeroelastic Behavior of Swept Wings—R. B. Brown, K. F. Holtby, and H. C. Martin.	0.50	0.75
291	Civil Air Regulations for Turbine-Powered Aircraft—George W. Haldeman.	0.35	0.75
289	The Minimum Drag of Thin Airfoils In Frictionless Flow—R. T. Jones.	0.35	0.75
288	Lateral Control of Personal Aircraft at High Lift Coefficients—Francis M. Rogallo.	0.35	0.75
287	Some Factors Affecting Large Transport Aeroplanes with Turboprop Engines (Wright Brothers Lecture)—A. E. Russell.	0.50	1.00
281	Turbine-Powered Transport Development—R. D. Kelly and Frank Davis.	0.35	0.75
280	Propulsion Analysis for Long-Range Transport Airplanes—A. Kartveli.	0.35	0.75
279	Optimum Performance of Rocket-Powered Missiles—Allen E. Puckett.	0.35	0.75
277*	Do We Need Turboprops?—E. V. Farrar and R. E. Johnson.	0.35	0.75
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264	A Recurrence-Matrix Solution for the Dynamic Response of Elastic Aircraft—John C. Houbolt.	0.50	0.75
263	A Mechanical Analogy for Hypersonic Flow—H. Reese Ivey.	0.35	0.75
262	Design and Operational Features of the Sikorsky 1,000-Hp. Helicopter Rotor Test Stand—Harry Jensen.	0.35	0.75
261	Kinematic Behavior of the Human Body During Crash Deceleration—E. R. Dye.	0.35	0.75
259	Analysis of the Elastic and Plastic Stability of Sandwich Plates by the Method of Split Rigidities—P. P. Bijlaard.	$0.65	$1.00
258	Types of Inelasticity of Structural Materials and Procedures of Design—Alfred M. Freudenthal.	0.50	0.75
257	An Initial Approach to the Overall Structural Problems of Swept Wings Under Static Loads—E. F. Sechler, M. L. Williams, and Y. C. Fung.	0.35	0.75
255	The Gyroscopic Effect of a Rigid Rotating Propeller on Engine and Wing Vibration Modes—R. H. Scanlan and John C. Truman.	0.50	0.75
254	The Solution of Aeroelastic Problems by Electronic Analogue Computation—Jonathan Winson.	0.50	0.75
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252	A Method of Determining Some Aerodynamic Coefficients from Supersonic Free-Flight Tests of a Rolling Missile—R. E. Bolz and John D. Nicolaides.	0.65	1.00
251	The Longitudinal Stability of Elastic Swept Wings at Supersonic Speed—Charles W. Frick.	0.50	0.75
250	The Rolling-Up of the Trailing Vortex Sheet and Its Effect on the Downwash Behind Lifting Wings—John R. Spreiter and Alvin H. Sacks.	0.65	1.00
249	On the Stability of Two-Dimensional Transonic Flows—Y. H. Kuo.	0.35	0.75
248	The Transient Temperature Distribution in a Wing Flying at Supersonic Speeds—Joseph Kaye.	0.65	1.00
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233*	Some Operational Aspects of Distance-Measuring Equipment in the Transitional Air Navigation System—J. Wesley Leas.	0.35	0.75
232*	The Development of a Course Line Computer for the Air Navigation System—Chester Watts and Francis Gross.	0.35	0.75

Preprints should be ordered by number from:

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News of Members

(*Continued from page 12*)

Members on the Move (continued)

Dr. Edward R. C. Miles (M.), Research Contract Director, Institute for Cooperative Research, The Johns Hopkins University. Formerly, Senior Mathematician, Applied Physics Laboratory, The Johns Hopkins University.

Capt. Howard Thomas Orville, U.S.N. (Ret.) (M.), Director of Engineering, Friez Instrument Division, Bendix Aviation Corporation.

Lt. Russell S. Paulnock, U.S.A.F. (T.M.), Base Flight Engineering, 57th Air Base Group, Elmendorf Air Force Base, Alaska. Formerly, Aeronautical Engineer, N.A.C.A., Langley Air Force Base, Va.

A. J. Perna (M.), Research Division, Research and Development Department, Pullman-Standard Car Manufacturing Company. Formerly, Professor, Newark College of Engineering.

Harris F. Reeve (A.M.), Safety Research Editor, Flight Safety Foundation. Formerly, Assistant Reviews Editor, AERONAUTICAL ENGINEERING REVIEW.

Howard E. Roberts (A.F.), Chief Engineer, American Helicopter Company, Inc. Formerly, Aero-Thermodynamics Engineer, Aerodynamics Section, Douglas Aircraft Company, Inc. (EDITOR'S NOTE: Mr. Roberts authored the paper published in the October, 1949, AERONAUTICAL ENGINEERING REVIEW, entitled "The Earth's Atmosphere.")

Richard H. Rosenberg (T.M.), Engineer, Fire Control, General Electric Company. Formerly, Graduate Student, Rensselaer Polytechnic Institute, Troy, N.Y.

William R. Ryan (M.), Vice-President in Charge of Engineering, Edo Corporation. Formerly, Director of Engineering, Edo Corporation.

Norman D. Sensenbaugh (T.M.), Engineering Draftsman, North American Aviation, Inc.

Merton A. Sigoda (T.M.), Man-Sew Corporation, New York. Formerly, Graduate Student, Massachusetts Institute of Technology.

Capt. Selden B. Spangler (F.), Commanding Officer, Naval Air Development Center, Johnsville, Pa. Formerly Director, Aircraft Maintenance, Bureau of Aeronautics, Navy Department, Washington, D.C.

Col. W. H. Tetley, U.S.A.F. (M.), Department of Mechanics, U.S.M.A., West Point, N.Y.

Harold H. Warden (M.), General Sales Manager, Propeller Division, Curtiss-Wright Corporation. Formerly, Manager, Installations Department, Propeller Division, Curtiss-Wright.

Louvan E. Wood (M.), Chief Engineer, Friez Instrument Division, Bendix Aviation Corporation. Formerly, Supervisory Engineer, Friez Instrument Division.

Corporate Member News

(*Continued from page 13*)

• Design Wins . . . The Navy has selected as the replacement for the World War II Grumman Avenger a design submitted by **Grumman Aircraft Engineering Corporation.** Two experimental models of the new carrier-based antisubmarine plane have been ordered.

• Booklet . . . A new 40-page hard-facing manual has been published by **Haynes Stellite Division,** Union Carbide and Carbon Corporation. The booklet, *Haynes Alloys—Hard-Facing Manual,* tells the complete story of hard-facing.

• Expansion . . . In keeping with the expanding requirements of the jet air age, **Lockheed Aircraft Corporation** has begun a $5,000,000 factory-expansion program. This modernization program includes the installation of giant fabricating machines and the construction of a new factory building.

• F-94 Delivered . . . The U.S.A.F. has taken delivery of the first production models of the F-94, manufactured by **Lockheed Aircraft Corporation.** It is a two-place ship, carrying a pilot and radar operator, and is designed as an all-weather jet fighter and interceptor.

• Underwater Flaps . . . Engineers at **The Glenn L. Martin Company** have come up with a pair of hinged, underwater flaps for P5M-1 Marlin flying boats which serve in the dual capacity of stern rudders for increasing maneuverability and brakes. Operated by the pilot, the flaps may be used individually or as a pair. Hydraulic power is actuated through electrical solenoids. The flaps may be opened to their full 65° angle, but an automatic spillover is provided so that if the pressure is too great the flaps will retract of themselves to a point where they can withstand the pressure.

• Combat Tanks . . . External gas tanks have been developed by **North American Aviation, Inc.,** to give the F-86 Sabre greater combat range and increased maneuverability. These new banana-shaped tanks are designed to be used throughout combat . . . North American has declared a dividend of 50 cents per share on its outstanding capital stock, payable on July 19 to stockholders of record on June 28.

• Research Program . . . The U.S.A.F. and the N.A.C.A. have launched a long-range research program with the X-4, manufactured by **Northrop Aircraft, Inc.** The X-4, powered by two gas-turbine engines, will explore the very high subsonic speeds. The extremely thin, swept-back wings of the research plane measure approximately 25 ft. in span, and the small fuselage is about 20 ft. long.

• New Service . . . **Pan American World Airways System** has inaugurated El Presidente, a deluxe extra-fare sleeper service between New York and Buenos Aires which will cut the scheduled time by almost 30 per cent.

• Anniversary . . . **Pratt & Whitney Aircraft Division,** United Aircraft Corporation, observed its 25th anniversary on July 26. On that date the Willgoos Turbine Laboratory, built at a cost of $12,000,000, was dedicated to the memory of Andrew Van Dean Willgoos, Chief Engineer of Pratt & Whitney from its founding until his death last year. The Willgoos Laboratory is considered the largest and finest privately financed jet research facility in the world.

• Buys Factory . . . **Republic Aviation Corporation** has purchased all of the buildings and the 500 acres of airport and plant area now occupied by the corporation from the General Service Administration, a U.S. Government agency. The purchase price was $5,332,000.

• Distributor . . . **Ryan Aeronautical Company** has announced the appointment of W. S. Kirkpatrick & Company, New York, as their distributor for Ryan Navion aircraft in Iran and Iraq.

• Helicopter to Canada . . . The Canadian Government accepted delivery June, 1950, on an S-51 helicopter, manufactured by **Sikorsky Aircraft Division,** United Aircraft Corporation.

• Crash Switch . . . **Simmonds Aerocessories, Inc.,** has announced their Inertia-Type Crash Switch, for providing split-second operation of fire-extinguishing equipment. This piston-actuated mechanism operates automatically at an air-frame deceleration of 3g or more.

• Hidden Arc Welding . . . In the fabrication of J47 turbojet components by the **Solar Aircraft Company,** the 18-8 stainless-steel parts are welded with a standard automatic head that uses an 18-8-type filler wire. The production line uses automatic hidden-arc welding.

• New Offices . . . **Trans World Airlines, Inc.,** have announced the opening of a new street-level ticket office in the International Building, 630 Fifth Ave., New York. T.W.A. will continue operating its present mezzanine ticket office in the same building . . . T.W.A. has opened a sales and executive office at 200 Piccadilly, W.1, London. Radio-teletypewriter links London with T.W.A.'s 70 other offices.

• Magneclutch . . . A commercially usable magnetic-particle clutch has been introduced by Vickers Electric Division, **Vickers Inc.** First developed for use by the Navy for operation of shipboard equipment such as radar, sonar, fire control, and other devices, it is now in production for use by industry for control of torque, speed, and position.

• Vibration Generator . . . The Aircraft Department, Westinghouse Small Motor Division, **Westinghouse Electric Corporation,** has produced a vibration generator for the purpose of determining the effect of intense vibration on airplane electrical equipment.

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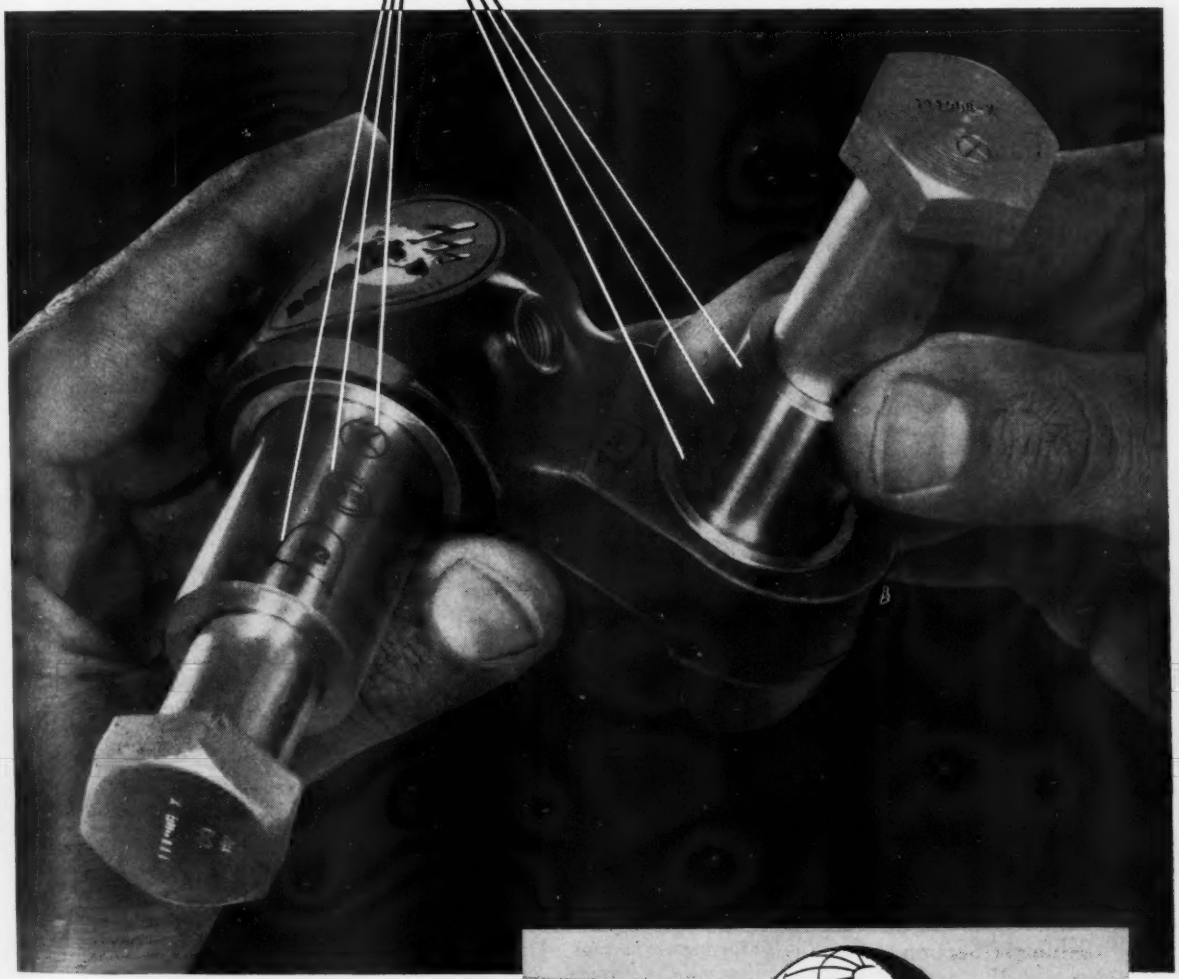

DEPEND ON DOUGLAS

30TH ANNIVERSARY YEAR

Meet Your Section Chairmen

George Nishan Mangurian

Baltimore Section

Back in 1929, George N. Mangurian surveyed the opportunities open in the various fields of engineering to a person with a structural background. He chose aeronautics and began his career that year by entering the employment of the Chance Vought Corporation. He was placed in charge of the structural analysis and structural testing of military aircraft and from 1935–1937 was Assistant Chief Structural Engineer.

▸ **Flying Boats**—The call of the large flying boat enticed Mr. Mangurian into becoming associated with The Glenn L. Martin Company in 1937. During his career with this company, he has been successively placed in charge of (1) structural analysis of wings on the M-146 and M-139, (2) a group of structural engineers designing the M-187, and (3) structural groups on such airplanes as the M-170, B-26, B-33, XB-35, XB-49, and the Northrop Flying Wing (which air-frame and power-plant installation was subcontracted to Martin from Northrop Aircraft, Inc.). In 1945, he was made Assistant to the Chief Structural Engineer on special assignments, and 2 years later he was made responsible for a group of about 100 engineers covering the following groups: Structural Development and Research; Dynamics and Flutter; Weight; and Structural Liaison. In 1948, he became Supervisor of Structures Projects and is presently in charge of groups, numbering about 75 men, responsible for the structural integrity of these aircraft: Martin 202; Martin 404; Air Force XB-51; Navy P4M-1; Pilotless Aircraft; and Structural Liaison Engineering.

▸ **M.I.T. Graduate**—Born in Springfield, Mass., 44 years ago, he was graduated from Massachusetts Institute of Technology in 1928 with a B.S. degree in Civil Engineering and in 1929 with an M.S. in Civil Engineering. He was coeditor of the text *Aircraft Structural Analysis*, which was published by Prentice-Hall, Inc.

Mr. Mangurian and his wife, the former Ethel Barton of Hartford, are the parents of three boys. He enjoys playing the piano and witnessing professional football and baseball games. Mr. Mangurian (M.), was one of those who helped to organize this section in 1947.

Kenneth Leland Burroughs

Chicago Section

As Vice-President of the Aeronautical University, Kenneth L. Burroughs is charged with the executive duties of coordinating all activities of the school, directing training, research, and public relations. He also does an extensive amount of traveling in behalf of the school to keep it posted on developments in the industry and to represent it at all important meetings and conferences.

▸ **Medicine vs. Aviation**—Originally, Mr. Burroughs had medicine in mind for his life work, but some flying experience in 1927 converted him inalterably to the cause of aviation. He enrolled in flying and other related courses offered by the University of Illinois, at which he was a student. After his graduation with a B.S. degree, he continued his flying activities and accepted employment with Curtiss-Wright.

In the fall of 1930, he became associated with the Aeronautical University as an instructor. During his 10 years as a teacher, he estimates that he delivered about 3,000 lectures on various aeronautical subjects. Since 1940, he has acted as administrator and director of training.

▸ **Training Aids**—Mr. Burroughs has developed mock-ups and many training aids and devices. One of his training films on the automatic pilot was ultimately used by the Navy. Prior to World War II, he was a Lieutenant in the Army Air Corps Reserve, and during the war he acted as the Director of the A.A.F. Contract Technical Training School at the Aeronautical University.

Aside from having held a pilot's license, he is a licensed airplane mechanic and aeronautical instructor. He is also registered in the State of Illinois as a professional engineer and is an accredited representative of the Governor's Committee on Veteran Rehabilitation and Employment. Mr. Burroughs, an Associate Fellow of the Institute, is also a member of the S.A.E. and A.S.E.E.

Mr. Burroughs was born in Chicago in 1907. He is married and is the father of two girls, aged 3 and 9. Golf, radio, and photography are his ways of relaxing after a tiring day.

I.A.S. Sections

Baltimore Section

Welcome W. Bender, *Secretary*

Erold F. Pierce, Manager, Technical Data Division, Wright Aeronautical Corporation, spoke on "Selection of Engines for High Performance Aircraft" at the May 17 meeting, which was held at Gilman Hall, The Johns Hopkins University.

▸ **Engine Analyses**—The speaker compared the performance characteristics of the turboprop, turbojet, and the turbojet with the afterburner. Such variables as speed required, range, altitude, thrust per square foot of frontal area, and specific fuel consumption are but a few of the important parameters. Mr. Pierce showed several slides of engine analysis, including comparisons of (1) performance at zero range, (2) gas generator fuel consumption, (3) performance with fuel drag loss for various hours of flight, (4) engine utilization for various ranges, and (5) zones of action at altitude. The turboprop combination showed up well for high-altitude, long-range operation, while the turbojet with and without the afterburner proved to have better performance characteristics at short

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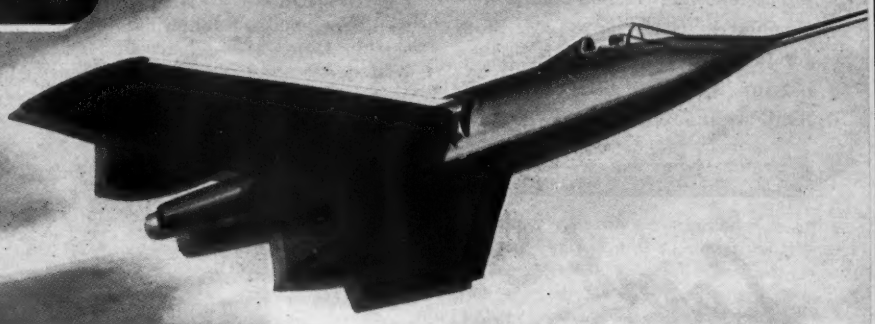

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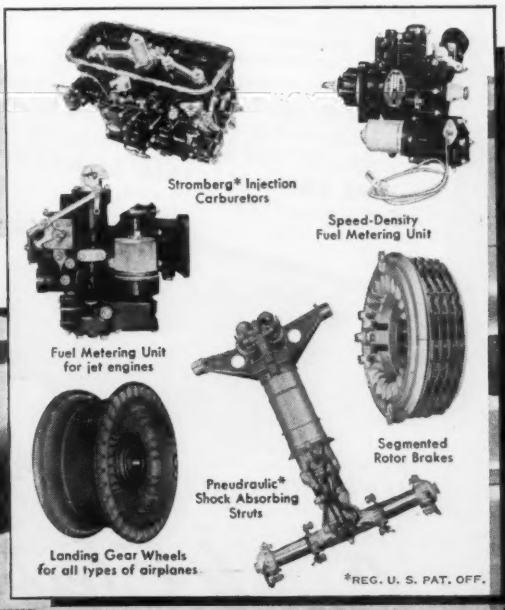
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range and high speed. In summarizing his talk, Mr. Pierce stressed the most important variables for the following performance factors: fuel consumption for a long range; engine weight for high speeds; and the power-weight ratio for high altitudes.

The following election results were announced: Chairman, G. N. Mangurian; Vice-Chairman, Capt. G. J. Higgins, U.S.N.R.; Secretary, H. E. Nietsch; and Treasurer, H. Pusin.

Chicago Section

Alfred F. Stott, *Secretary*

At the June 13 business meeting, Dr. Harvard L. Hull, Director, Remote Control Division, Argonne National Laboratory, was unanimously elected Chairman of the Advisory Board. The retiring Section Chairman, Harold V. Hawkins, was appointed Historian. Other appointments included the following: Membership Committee Chairman, Jack Witten; Program Committee Chairman, Robert Wendt; Greeting Committee Chairman, O. J. Engle; and Nominating Committee Chairman, Wallace M. Frei.

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Dayton Section

R. W. Hoeflein, *Secretary*

The May 25 meeting, with Chairman A. F. Arcier presiding, was held at the Biltmore Hotel. The speaker was Jerome Lederer, Director, Flight Safety Foundation, who spoke on "Notes on Civil Air Safety."

▸ **Human Engineering**—In discussing the problems of safety on commercial air lines in the United States today, Mr. Lederer stated that, while we have capable technical engineers who do outstanding work in designing modern complex airplanes, something seems to be lacking in the "Human Engineering" phase. He defined "Human Engineering" as being that element in engineering which deals with predicting and designing for human action or behavior in emergencies to produce the most favorable or safest aircraft under emergency conditions. This element, he stated, was one of the most important factors in air safety. The records show that commercial air travel is becoming safer each year. Air safety in the future should be greatly increased by new methods of ground control, radar navigation, and understanding and utilizing the "Human Engineering" phase of civil air transportation.

A film was shown which had been produced by a civil air line. It covered crew-training techniques in meeting emergencies of all kinds on current commercial aircraft.

Hagerstown Section

L. T. Waterman, *Secretary*

The May 23 meeting, held in the Moose Hall, was called to order by Chairman Dan Weller. An illustrated lecture was presented by F. N. Piasecki in which he discussed the history and design problems of helicopters, as well as performance parameters and blade structural considerations. After the talk, a color film of the development and testing of the PV, and later the Piasecki machines, was presented. Sixty members attended.

Los Angeles Section

H. A. Storms, *Secretary*

The May 4 Specialists' Meeting was held in the I.A.S. Building with W. F. Ballhaus as presiding chairman. The topic for the evening was "Power-Control Systems for the Primary Flight Controls on Airplanes."

T. A. Feeney, Northrop Aircraft, Inc., spoke on the development of power-control systems at Northrop and showed slides to present diagrammatically the principles of the various parts of the control system. Mr. Feeney also discussed the problems of valve design and of valve sticking from foreign material in the hydraulic fluid. He commented on the use of controlled center leakage to improve valve stability and the advantage of power controls in providing positively held control surfaces and in providing control forces to the pilot independent of the hinge moments at the control surface.

The second speaker was C. G. Gordon, North American Aviation, Inc., who discussed "Pilot Operated Power Systems for Aircraft Control." The problems associated with flight at high Mach Number were summarized to show the reasons for development of power controls in place of wing high-boost ratios based on control-surface hinge moments and satisfactory pilot-effort loads. The characteristics of a power-control system were also described.

The meeting was attended by 135 members and guests.

▸ **Atomic Energy**—The honored guest of the evening at the May 18 meeting was J. Carlton Ward, Jr. Before introducing the speaker, Mr. Ward briefly reviewed the origin of atomic energy investigations in the United States and the subsequent steps taken by the Government to apply to this source of propulsion to aircraft.

The speaker of the evening was Lee A. Ohlinger, Chief, Computing Section, Northrop Aircraft, Inc. Mr. Ohlinger first reviewed the basic concepts of nuclear physics and nuclear composition and then proceeded to the practical utilization of atomic energy. He stated that a practical installation in a vehicle of some description must incorporate the following: (1) moderator; (2) fissionable material; (3) shielding—of great importance and greatest weight; (4) controls; and (5) heat exchanger. Any atomic-powered vehicle must, therefore, be of a large size in order to accommodate these parts. However, before practical application can be made, these problems must be solved: (1) suitable control of power plant; (2) protection of occupants from radiation; and (3) suitable heat exchangers capable of handling the extremely high temperatures encountered.

The meeting was opened by Secretary H. A. Storms, who introduced the Honorary Chairman, E. P. Hetzel. Two hundred and fifty members and guests were in attendance.

▸ **Test Hop**—On the night of June 3, a dance sponsored by the Section was held in the I.A.S. Building. As this dance was a "first" for the section, the theme "Test Hop" was appropriate. The dance committee was headed by Dr. A. E. Puckett. Approximately 100 couples were present.

▸ **Fallacies in Research**—The June 22 meeting was called to order by the Chairman, P. A. Colman, who presented J. H. Kindelberger, I.A.S. President. Mr. Kindelberger introduced the guest speaker, Capt. Walter S. Diehl, U.S.N., F.I.A.S., Assistant for Research Liaison, Office of Assistant Chief, Bureau of Aeronautics, Navy Department. Captain Diehl's topic for the evening was "Common Fallacies of Aeronautical Research."

Captain Diehl stressed the necessity of a proper understanding of the term research. He discussed the main fallacies in aeronautical research and related fields under the following headings: (1) general; (2) financial; (3) personnel; (4) program; (5) facilities; and (6) reports. Captain Diehl emphasized the need of research in the field of research.

The meeting was attended by 250 members and guests.

Student Branches

University of Florida

The Scholastic and Lecture Awards were presented to William Franklin Roberts at the May 16 meeting.

The following officers were elected: Chairman, Costa Francisco; Vice-Chairman, Blake Wallace Lambert; Corresponding Secretary, Glen Nickerson; Recording Secretary, Joseph A. Marquis; and Treasurer, Lee Ramage Trotter.

Chairman Edward Carrington Allison presided.

Georgia Institute of Technology

On July 7, the following new officers were announced: Chairman, Thomas P. Browne; Vice-Chairman, John A. Bachman; Secretary, Robert E. Ricles; and Treasurer, Hazle B. Terry.

A film, *Air Power Is Peace Power*, was shown. Chairman Thomas P. Browne presided, and 20 persons attended.

University of Kansas

It was announced by the I.A.S. Student Officers and members of the faculty that the scholastic award was won by I-T'an Yu and the lecture award was won by Giles K. Smith for his report on the "Upper Atmosphere Phenomena."

University of Minnesota

The speaker at the April 11 meeting was Edward Silberman, Assistant Professor, St. Anthony Falls Laboratory. He spoke on the "Facilities Available at the St. Anthony Falls Laboratory" and outlined its main functions. The lecture was followed by a tour of the laboratory.

On May 3, Vice-Chairman Harlan Smith presided at the meeting at which the following officers were elected: Chairman, James P. Lindberg, Jr.; Vice-Chairman, James A. Winker; Treasurer, Vernon O. Loveless; and Publicity Chairman, Keith R. Thorson.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to Associate Fellow Grade

Davies, Handel, M.Sc., Head, Aerodynamics Flight Research Section, Ministry of Supply (England).

Elected to MEMBER Grade

Bernat, E. P., Dipl. Ing., Lecturer in Applied Math., Polish University College.

Brocard, Jean, A.E., Chief Engineer, Louis Breguet Co.

Chausse, Ronald H., B.S. in Ae.E., Aerodynamicist, North American Aviation, Inc.

Gray, Landon R., Vice-President, Hufford Machine Works, Inc.

Hansel, Sydney, Dipl. in Ae.E., President, Hansel Engineering Co.

Harris, Darrol N., B.S., Senior Engineer, Shell Oil Co.

Lassam, J. P., Senior Design Draughtsman, Grade 1, A. V. Roe Canada Ltd.

Parker, Charles A., Aero. Engineer, Naval Aviation Armament Lab., Naval Air Development Center (Johnsville).

Rollin, Vern Gordon, B. of M.E., Acting Chief, Icing Research Branch, Lewis Flight Propulsion Lab., N.A.C.A.

Smith, Fred G., C.E., Group Leader in Charge of Structural Tests, Grumman Aircraft Engineering Corp.

Smith, William D., B.S. in M.E., Equipment Design Engineer, Douglas Aircraft Co., Inc. (Long Beach).

Townsend, E. N., Technical Mgr. (North America), British Overseas Airways Corp.

Transferred to MEMBER Grade

Brown, Joel E., M.S. in Ae.E., Aerodynamicist "B," Douglas Aircraft Co., Inc. (Santa Monica).

Dommers, Walter A., B. of M.E., President, The Dommers Co.

Goldbaum, George Charles, B.S., Aerodynamicist, Missiles Group, Douglas Aircraft Co., Inc. (Santa Monica).

Elected to Associate Member Grade

Halford, Robert G., Aviation Editor, *Aircraft and Airport Magazine,* Farm Equipment Publishing Co.

Sechler, Charles W., Supervisory and Staff Capacities, Production Control Div., Lockheed Aircraft Corp.

Elected to Technical Member Grade

Aron, Walter, B.S. in M.E. (Aero.), Aeronautics Engineer, Radioplane Co.

Di Quilio, Mario S., B.S., Research Stress Engineer, Bell Aircraft Corp.

Gulshen, Francis J., B.S.M.E., Naval Aviation Cadet, Naval Air Station (Pensacola).

Lynch, E. J., Lab. Technician, Aircraft Div., A. V. Roe Canada Ltd.

Slagle, Grady M., Jr., M.S. in M.E., Engineer—Designer, Air Conditioning Design Group, Douglas Aircraft Co., Inc. (El Segundo).

Transferred to Technical Member Grade

Adelizzi, John T., B.S.Ae.E.

Augustyn, Joseph F., B.S. in Ae.E.

Booth, Richard B., Engineering Draftsman, North American Aviation, Inc.

Brady, James J., Stress Analyst, H. L. Yoh Co. (Consulting Engineers).

Brady, W. Gordon, A.E., Graduate Student, Brown University.

Capobianco, A. M., B. of Ae.E., Engineering Buyer, Purchasing Dept., Burns & Roe, Inc. (Engineering Consultants).

Clarke, Joseph H., Jr., B.Ae.E., Research Asst., Aerodynamic Lab., Polytechnic Institute of Brooklyn.

Cumberpatch, James R., B. of Ae.E., Capt., U.S.A.F.; Assigned to the U.S.A.F. Institute of Technology.

Danielson, Glen R., B.S.Ae.E., Engineering Draftsman, Douglas Aircraft Co., Inc. (El Segundo).

Dutton, James J., B. of Ae.E., Student, Oak Ridge School of Reaction Technology, Atomic Energy Commission.

Dziepak, Anthony J., B.A.E.

Farmer, William G. D., B.A.Sc., Assistant in Aerodynamics, Canadair, Ltd.

Feldman, Jerry J., B.S. (Aero. Tech.).

Fischer, Robert L., B.S. in Ae.E.

Fraser, William T., B.A.Sc., Draftsman, A. V. Roe Canada Ltd.

Frost, Richard C., B.S.Ae.E., Student & Research Assistant, University of Michigan.

Gardner, Richard N., B.Ae.E., Research Fellow, The Ohio State University.

Gibson, Walter M., B.A.Sc., Draughtsman, Design Office, A. V. Roe Canada Ltd.

Gottschalk, George F., B.Ae.E.

Gutstadt, L. R., B.E.-A.E.

Hahn, William C., B.S.Ae.E.

Hake, Richard D., B.A.Sc., Meteorologist, Grade 1, Meteorological Div., Dept. of Transport (Malton).

Hall, Charles M., III, Liaison Engineer, Data Transmission Specialist, Northrop Aeronautical Institute.

Hambleton, John A., S.B.

Holt, Robert L., B.S.A.E., Engineering Asst., Consolidated Vultee Aircraft Corp.

Hurt, Hugh H., Jr., B.S., Weight Analyst "A," Preliminary Analysis Section, Aerophysics Lab., North American Aviation, Inc.

Ilgen, Mary L., B.S. in Ae.E., Aerodynamicist, Douglas Aircraft Co., Inc. (Santa Monica).

Jackson, Victor G., M.S. in M.E., Research Engineer, Hydrodynamics Lab., California Institute of Technology.

Joy, Warren, B.S., Engineer, Aircraft Gas Turbine Div., General Electric Co.

Kell, Robert J., B.S.Ae.E., Graduate Student, School of Aeronautics, Purdue University.

Kraemer, Robert S., B.S. in Ae.E., Graduate Student, California Institute of Technology.

Kutney, John T., B.S. (Aero.), Draftsman, Fuller Co.

Lesley, Ralph, B.Ae.E., Airline Maintenance Engineer & Instructor, Israeli National Airlines, Government of Israel.

Lewis, W. G., B.A.Sc., Meteorologist, District Aviation Forecast Office, Dept. of Transport (Montreal).

Lieblein, Seymour, B.M.E., Mechanical Engineer, Lewis Flight Propulsion Lab., N.A.C.A.

Loria, John C., S.B., Graduate Student, Massachusetts Institute of Technology.

Lovatt, Jack D., B.S. in Ae.E., Jr. Engineer, Aircraft Design Div., A. V. Roe Canada Ltd.

MacEwan, Robert G., B.S.Ae.E., Test Engineer, Allison Div., General Motors Corp.

Marlin, Donald L., B.A.Ae.E., Aero. Engineer, Ryan Aero. Co.

Miller, Bernard P., B.S.Ae.E.

Montanaro, C. G., Jr., Inspector, Northrop Aircraft, Inc.

Moore, Lavon L., B.S. in Ae.E., Computer, Boeing Airplane Co. (Seattle).

Officer, R. G., B.A.Sc., Flight Cadet (Officer's Training Course), Royal Canadian Air Force.

Pandalai, K. A. V., M.Ae.E., Member of Research Staff, Aircraft Structures Research Office, Polytechnic Institute of Brooklyn.

Parker, John W., Technical Illustrator "B," North American Aviation, Inc.

Parsons, William E., B.S., Engineering Draftsman "C," Douglas Aircraft Co., Inc. (El Segundo).

Perruzzi, Carmen, Jr., Draftsman, The Glenn L. Martin Co.

Petraglia, John P., Draftsman, The Glenn L. Martin Co.

Rabenberg, Berle E., Engineering Draftsman "B," North American Aviation, Inc.

Rattinger, Ivan, B.A.E.

Reiss, Howard R., B. of Ae.E., Research Asst., Aero. Lab., Polytechnic Institute of Brooklyn.

Rhodebeck, Charles E., B.S.Ae.E., Asst. Engineer, Regent Aircraft Corp.

Roberts, William F., B. of Ae.E., Engineering Trainee, Chance Vought Aircraft Div., United Aircraft Corp.

Sadlocha, Stanley, B.S.A.E.

Smetana, Frederick O., B.S.M.E. (Aero.).

Smith, Giles K., B.S.Ae.E., Student, University of Kansas.

Somerville, Robert H., Electrical Designer, Hanford Atomic Energy Project.

Stalk, George, B.S. in Ae.E., 1st Lt. & Radar Officer, U.S.A.F., Keesler Air Force Base.

Stannard, Edward A., B.M.E., Graduate Student, Cornell University.

Tappe, William C., Draftsman, The Glenn L. Martin Co.

Tucker, Norman B., B.Sc. in Ae.E.

Vrabel, Robert J., B.S. in Ae.E., Field & Service Mech., Consolidated Vultee Aircraft Corp. (Fort Worth).

Wagner, Raymond S., B.S.M.E., Test Engineer, General Electric Co.

Warner, Robert W., S.M., Research Engineer, Massachusetts Institute of Technology, Div. of Industrial Cooperation.

Walsh, Eugene J., B.S.Ae.E.

Welch, Frank, Jr., A.E., Lt. Comdr. & Naval Aviator, U.S. Navy.

Whetstone, Jabez C., B.A.E., Flight Test Analyst, Douglas Aircraft Co., Inc. (Santa Monica).

Wilson, Robert E., S.M., Test Engineer, General Electric Co.

Wurtele, D. B., B.A.Sc., Project Engineer, Experimental & Proving Establishment, Royal Canadian Air Force.

Yu, I-T'an, M.S. in Ae.E., Designer, Shih & Associates.

Reprints of "The Earth's Atmosphere" Now Available

In view of the unprecedented demand for the article "The Earth's Atmosphere" by Howard E. Roberts (*Aeronautical Engineering Review*, Volume 8, Number 10, October, 1949), we have reprinted the article and are making it available, together with the chart on the Characteristics of the Earth's Atmosphere, to all who are interested in obtaining copies.

Reprints of the article, including the chart, may be obtained for 65 cents (members) or $1.00 (non-members) by writing to:

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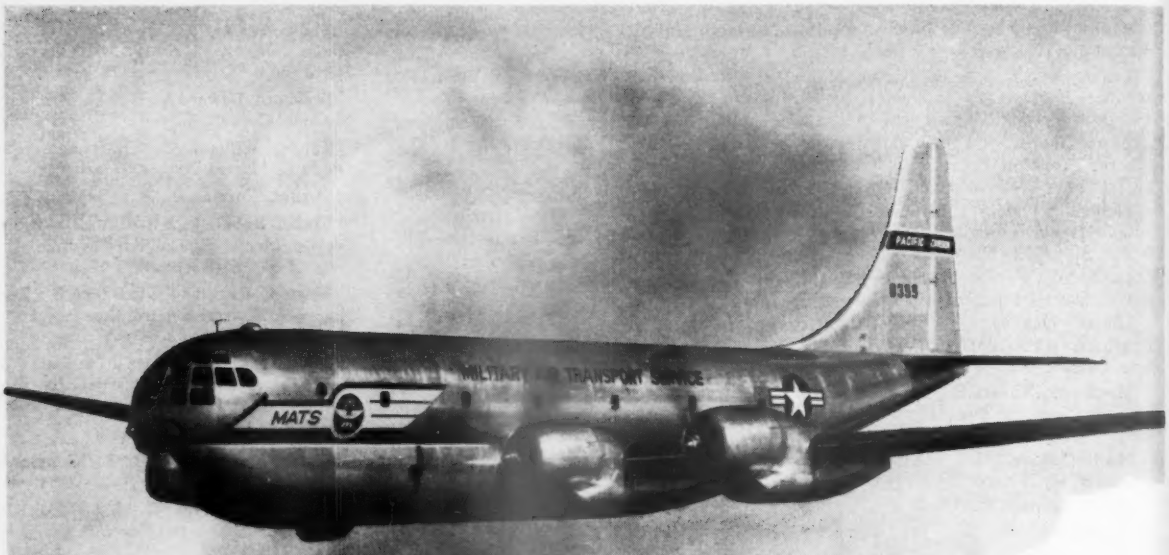

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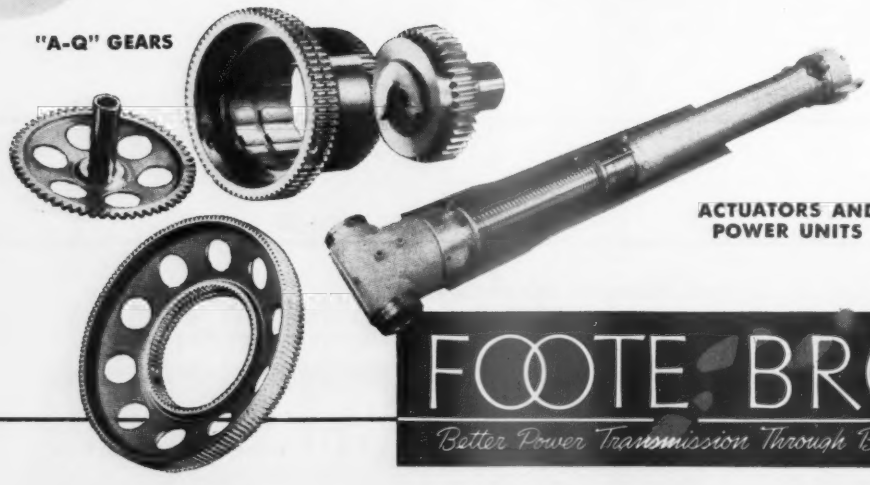

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Personnel Opportunities

This section is for the use of individual members of the Institute seeking new connections and organizations offering employment to Aeronautical specialists. Any member or organization may have requirements listed without charge by writing to the Secretary of the Institute.

Wanted

Thermodynamicist—Advanced training with Master's or Doctor's degree. Aeronautical experience desirable. **Structures Engineer**—Aeronautical degree with at least 3 or 4 years' aircraft experience in structural analysis. Civil Engineers with similar experience will also be considered. **Weights Engineer**—Technical graduate, considerable experience in preliminary design in connection with weights work. Should possess estimating ability. **Senior Development Engineers**—Group Leader; educational background in physics, or electrical, or mechanical engineering. Applicable experience in such fields as gyros, servos, intricate machine design, mechanics, or dynamics. Technical ability is of foremost importance. **Helicopter Engineers**—(A) Mechanical Engineers experienced in engine work, helicopter design, or aircraft control systems. (B) Aeronautical or Structural Engineers with a degree plus 4 to 5 years' experience in sheet-metal construction. (C) Electrical Installation Engineer with a college degree or equivalent, 2 to 3 years' experience in actual installation design work. NOTE: Profound interest in the designing and building of helicopters is essential for these positions. **Chief, Systems Test Engineer**—Technical graduate; at least 3 to 5 years of experience including various types of systems test; 60 per cent electronics and related experience such as instrumentation work, leadership ability essential. **Test Engineers—Missiles**—Electronics or Radio Engineering degree or equivalent with considerable experience in electronic circuitry. **Senior Dynamics Engineer**—A Master's or Doctor's degree in applied mathematics or physics, or aeronautical engineering with emphasis in dynamics and vibrations. Some experience in servomechanisms, flutter and vibrations, or stability desirable. Position also available for Electronics Engineer with mathematical ability and interest in dynamics work. **Research Dynamicist**—Advanced education in applied mathematics with experience in operations research. Include a comprehensive résumé with each inquiry, and address all replies to: R. C. Marks, Manager, Engineering Personnel, Bell Aircraft Corporation, P.O. Box 1, Buffalo 5, N.Y.

Aerodynamics Engineer—M.S. degree, theoretical knowledge, and practical experience with high-speed aerodynamic design, performance, and dynamic stability problems. These qualities, plus the capacity for original thinking, are required to become an associate in a firm concerned only with research and development work. Send résumé to Van Zelm Associates, 28 E. 21st St., Baltimore 18, Md.

Engineering & Physicists—Higher degrees preferred. Several years' experience in analysis and design in the following fields: electronic circuits—pulse networks, video amplifiers, timers, triggers. Magnetic recording—magnetic and associated electronic circuits. Apply employment office, Northrop Aircraft, Inc., 1001 East Broadway, Hawthorne, Calif.

Senior Electronics Engineers—B.S. or M.S. degree and 3 years' experience in radar, television, pulse, video, or display circuit design. Salary range $375–$535 per month. **Electronics Engineers**—B.S. degree and 2–3 years' experience as noted above for Senior Electronics Engineers. Salary range $325–$430 per month. **Digital Computer Design Engineers and Automatic Telephone Switchboard Design Engineers.**—Salary range $480–$639 per month. **Senior Electromechanical Engineers**—Degree and a minimum of 4 years' experience in servomechanisms, analog computers, special weapons, or system design. Salary range $375–$535 per month. Send résumé to Employment Department, The Glenn L. Martin Company, Baltimore 3, Md.

Flutter and Vibrations Engineer—Must have 4 years' experience in flutter and vibrations analysis of airplanes and airplane components; also must be capable of handling dynamic loads and aeroelasticity and should have some knowledge of electronics. Apply Curtiss-Wright Corporation, Technical Employment Office, 4300 E. Fifth Ave., Columbus 16, Ohio.

Preliminary Designers—With a minimum of 5 years' aircraft experience for design and analysis work in structures, thermodynamics, aerodynamics, and problems in power-plant and equipment installations. Inquiry should include comprehensive experience résumé. Address: Manager, Engineering Personnel, Bell Aircraft Corporation, P. O. Box 1, Buffalo 5, N. Y.

Design Engineers—Design engineers with 3 to 10 years' aircraft design experience needed to assist in design of high-performance military aircraft. Salary commensurate with training and experience. Chance Vought Aircraft, Dallas, Tex.

Design Engineers—For work on heavy-type bomber aircraft. Requires a B.S.E. and a minimum of 5 to 10 years' aircraft experience in wings, landing gear, controls, empennage, hydraulics, and body and electrical design. Please direct reply to Administrative Engineer, Boeing Airplane Company, Wichita Division, Wichita, Kan.

Research Positions—Open for physicists, mathematicians, and statisticians with the Naval Ordnance Test Station, Pasadena, Calif. Real opportunity is offered to high-caliber scientific personnel to work with top management in evaluation of weapons research and development. These are Civil Service positions GS-11 to GS-15 ($5,400 to $10,000). Reply with brief outline of education and experience to Personnel Department, Naval Ordnance Test Station, 3202 E. Foothill Blvd., Pasadena, Calif.

Preliminary Analysis and Design Engineers—Must have 3 to 10 years' aircraft experience with minimum of 2 years in aircraft or missile preliminary analysis and design. Advanced degrees and experience in supersonic design, configuration analysis, and economic evaluation are particularly desirable. **Aerodynamics Engineers**—To perform studies in supersonic aerodynamics on extensive guided-missile program. Positions open for men with training and experience in dynamic stability, performance, configuration development, aerothermodynamics, and flight testing. Salary dependent on qualifications. Address Aerophysics & Atomic Energy Research Division, North American Aviation, Inc., 12214 Lakewood Blvd., Downey, Calif.

215. Research Scientist—Advanced degree and 5 to 10 years' experience for responsible position to handle theoretical and experimental projects in the field of engineering mechanics. Subjects of particular interest include nonlinear mechanics, dynamic loading of flexible structures, fatigue of structural components, and machine methods of computation. Salary and opportunities depend entirely upon individual qualifications. Location is Southwest.

206. Aircraft Design Engineer—Graduate engineer with minimum of 10 years' aircraft experience in hydraulic systems for heavy aircraft. Design of good, practical aircraft components that may be required for proper installation of the units of hydraulic systems necessary. Particular experience in design or landing-gear components desirable. Give details of experience and past earnings in letter of application.

204. Assistant or Associate Professor of Aeronautical Engineering—To teach aircraft design and propulsion courses in the Aeronautical Engineering Department of a well-known eastern institution. Previous teaching experience and advanced degrees desirable. Service for 10-month academic year. Salary dependent upon qualifications. Inquiries should include summary of educational and industrial experience.

203. Chief Inspector—East coast helicopter manufacturer requires highly qualified inspector qualified to accept responsibility for administration and organization of inspection department, dealing with AN contracts. Excellent opportunity for right man. Give details in first letter.

202. Engineers—East coast helicopter manufacturer requires experienced personnel to permit rapid expansion of engineering department. Has immediate need for structural design engineers, mechanical design specialist, weight engineer, stress analysts, senior draftsmen. Minimum 5 years' experience. Knowledge of AN design standards desirable. Give details in first letter.

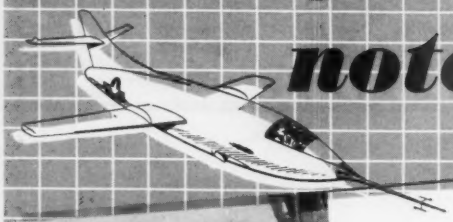
196. Engineers—Well-known aircraft company in Southern California now has attractive openings for Aerodynamicists, Hydrodynamicists, and Aero-Thermodynamicists. Candidates with supervisory potential, above average technical ability, and not less than 5 years' experience, preferably on flying boats, will be favorably considered. This is an ideal opportunity. Include in reply a complete description of your education, experience, ingenuity, and salary expected.

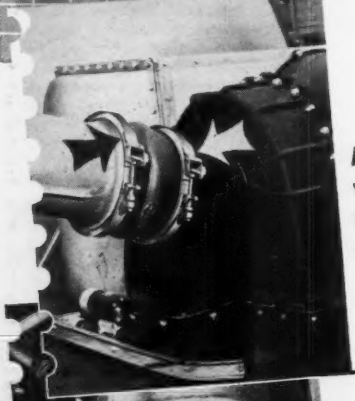
The number preceding the notices represents the Box Number of the Institute of the Aeronautical Sciences to which inquiries should be addressed.

Available

219. Aeronautical Engineer—Holds aircraft and engine mechanic's license. Has experience

engineer's notebook





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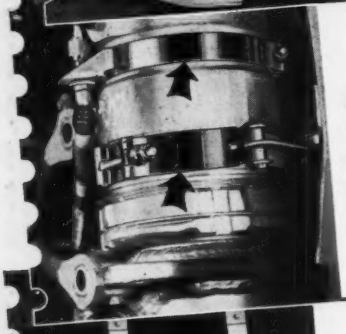

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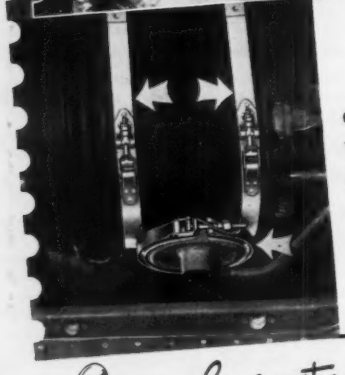
Marman straps provide an easy method for supporting fairing from the hydraulic strut itself...an excellent means for holding hydraulic lines in place as well.



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in repair, maintenance, and operation of aircraft radio. Desires position in which experience can be utilized.

218. Hydraulics and Pneumatics Engineer—Mechanical Engineer with 10 years' aeronautical experience including 4½ years test, development, and design on rocket motors and components. Has worked on projects dealing with extreme high and low temperatures. Desires responsible position in West with stable development organization on contract basis. California Registered Engineer. Age 32.

217. Research Engineer—S.M. in Aero. Eng. One year's experience in aircraft production; two years in stress analysis and preliminary design; three years in aerodynamics research. Desires project engineering staff position in industry, involving application of theoretical aerodynamics and structures to problems in basic design and development. Location open.

216. Thermoaerodynamicist—Wide experience in turbojet, rocket, and reciprocating power plants; subsonic, transonic, and supersonic aerodynamics. Available for responsible position in new airplane or engine development group.

214. Aeronautical Engineer—(Industrial Option); B.A.E., 1949, New York University. One year's experience in machine shop and tool designing (jigs, fixtures, and machine tools). Assisted in original design and engineering analysis of self-contained heating unit to operate at sub-zero temperatures. Desires position as junior engineer or engineering draftsman. Single, age 24. Location open. Available immediately.

212. Design Engineer—Graduate, B.S.A.E., with eleven years' aircraft experience in various phases of design, development, research, and sales. Particular concentration on hydraulics, landing gear, jet-engine accessories, and lubrication. Capable of taking full responsibility for group or working as member of team.

210. Staff Engineer—Ten years' experience in related Mechanical-Aero.-Thermo. problems in practical design, development, test, and advanced theory. Location open.

209. Sales Representative—Sales management experience. Direction and coordination of sales and engineering departments. Experienced in Government contracts. Sale of products requiring high-level engineering in aviation and general industry, controls for industrial use, and electronic equipment for specialized uses. Good business judgment and past sales record. Location—Los Angeles and San Francisco area.

208. Flight-Test Engineer—B. Aero. E. Six and one-half years' experience in flight test, research, and aerodynamics. Flight-test experience that covers instrumentation, operations, planning, and analysis was gained in both a civilian and military status. Research experience includes missile guidance systems and supersonic aerodynamics. Age 29. Location open. Desires position with a challenge.

207. Aviation Executive—Ten years' experience covering sales and service representation, production management, and managing directorship with reliable firms in the aviation field. Extensive travel in Far East as consultant on air-freight operations and factory methods. Age 37. Location open. Further data on request.

205. Mechanical Engineer—Licensed Professional Engineer. Eleven years' experience: 2 years of teaching evening classes, Washington University, St. Louis, Mo. Supervisory experience includes 3 years as Chief of Design, I

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year as Project Engineer (power plant), 1 year as Group Engineer (power plant), 1 year as Lead Man (power plant and preliminary design). Active Wright Field and BuAer contacts 1943–1945; active C.A.A. Washington contacts 1945–1946. Experienced in preliminary design (8 years), including practical estimations of manpower (shop and engineering) and material costs. Diversified experience ranges from complete airplane and guided-missile design to components, including liquid-oxygen test devices, injector plates, rocket-motor shells, high-speed bearing application, miniature power plants, and optics systems for seekers. Will consider supervisory or administrative work with a small, aggressive, and well-financed group. Currently holds two Professional (P-6) Civil Service Ratings.

200. Aircraft Equipment Sales Engineer—Engineering Degree. Six years of sales office management; 9 years of aircraft company design. Hydraulic, power-plant, and missile equipment manufacturers' type of work. Has handled liaison work with services. Air-frame service engineering. Willing to relocate. Desires sales or engineering coordination work with air-line, equipment, or air-frame company.

199. Instrument Department Head—Aircraft or Industrial; Liberal Arts degree; aircraft instrument training course, Omaha University; Instructor, electronics theory, U.S. Signal Corps. Instrument technician and instrument laboratory foreman; later flight-test and engineering tests of instrumentation for B-29 last 10 months of war. Foreman industrial instrument department, ordnance plant. A total of 8 years' instrument experience: 5, aircraft; 3, industrial, covering indicating, recording, and controlling instruments of pneumatic, electrical, and electronic applications, and drafting, designing, engineering report writing. Member of The Instrument Society of America.

198. Aeronautical Engineer—Age 25. Graduate of the Academy of Aeronautics in aircraft Design and Construction, August, 1949. One and one-half years' civilian and 3 years' military experience in aircraft and engine overhaul and maintenance. Background includes "E" license. Eight months with aircraft-engine manufacturer as balancer and spin tester of the J-47 jet turbine and shaft. Desires position as junior engineer in the East Coast area.

197. University Teaching—Wind-tunnel Operation—Wind-Tunnel Assistantship and M.S. in Aeronautics, CalTech. Ten years' experience all phases aerodynamics with several aircraft manufacturers. Specializing in wind-tunnel testing, including model design, testing and tunnel operation, analysis of results, and company representation. Position teaching and wind-tunnel operation desired.

195. Pilot—Aeronautical Engineer—B.S. Aero. E., Aeronautical University of Chicago. Five years' general design experience; includes 1 year of specialization in guided-missile-design research and proposal work; consultant on two private aircraft research projects; 1 year of specialization in aircraft hydraulics systems design, installation, and actuator design; varied experience in building structures design and in architecture. Rated in U.S.A.F. (R.O.C.) as Engineering Design and Development Officer (MOS 7050). Has current multiengined (Land) commercial pilot license. Majority of time is in B-25 and P-38 type aircraft; currently active in Air National Guard flying C-47 type aircraft. Desires permanent position, with avenues for advancement, in missile-design research and development program or flight test with an established and progressive firm. Prefers Mid-West to Western United States or abroad.

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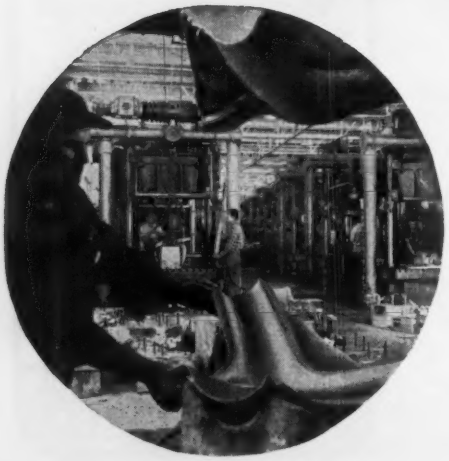

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